Fishery Data Series No. 18-32

Anchor River Chinook Salmon Escapement, 2012

by

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and

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December 2018

Alaska Department of Fish and Game Divisions of Sport Fish and Commercial Fisheries

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat or long
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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ABSTRACT

The 2012 Anchor River Chinook salmon (*Oncorhynchus tshawytscha*) escapement was estimated using a dual-frequency identification sonar (DIDSON) during high spring flows and by a resistance board weir fitted with an underwater video once flows subsided. Chinook salmon escapement (4,509 fish; SE 100) fell within the sustainable escapement goal (SEG) range of 3,800–10,000 fish. The midpoint of the Chinook salmon run was 13 June. The daily Chinook salmon escapement counts were positively correlated with daily average river stage, but not with daily average river temperature. The Chinook salmon dominant age class was ocean-age-3 (50.4%; SE 4.0%). Overall mean length of males (603 mm; SE 15.4) was smaller than that of females (755 mm; SE 7.4). The inriver sport fishery was restricted by a series of emergency orders that probably resulted in the lowest estimated harvest (38 fish) on record.

Key words: Anchor River, Chinook salmon, *Oncorhynchus tshawytscha*, steelhead, *Oncorhynchus mykiss*, kelt, emigration, run timing, diel, sustainable escapement goal, stock status, weir, sonar, DIDSON

INTRODUCTION

The Anchor River is located on the southern portion of the Kenai Peninsula (Figure 1) and supports the largest Chinook salmon (*Oncorhynchus tshawytscha*) run in the Lower Cook Inlet Management Area (LCIMA) with estimated total runs ranging from about 4,100 to 13,600 fish (2003–2011; Kerkvliet et al. 2016). Three streams are open to sport fishing for Chinook salmon in the LCIMA: Anchor River, Deep Creek, and Ninilchik River. In Alaska, most juvenile Chinook salmon remain in fresh water until the following spring when they migrate to the ocean as smolt in their second year. Based on scale age data, Anchor River Chinook salmon spend 1 to 4 years feeding in salt water before they return to spawn (Kerkvliet and Booz 2012). Run timing of adult Chinook salmon into these streams is approximately early May through late July with a peak in early to mid-June (Kerkvliet et al. 2008; Kerkvliet and Burwen 2010; Kerkvliet and Booz 2012; Kerkvliet et al. 2012).

The Anchor River watershed is approximately 587 km^2 with about 266 river kilometers (RKM) of anadromous streams (Table 1). The Anchor River has 2 major forks (south and north forks) and their confluence is located approximately 2.8 RKM upstream from the mouth. The south fork watershed is approximately twice the size of the north fork watershed. Because of the Anchor River's small size, geomorphology, and vegetation, water flows can rise substantially following heavy rains.

Anchor River Chinook salmon are primarily harvested during an inriver sport fishery. The inriver sport fishery is restricted by regulation through small daily and seasonal bag limits, and limits on days and areas open to sport fishing. The annual Chinook salmon catch and harvest in the Anchor River sport fishery is estimated by the Statewide Harvest Survey (SWHS; Table 2). From 2003 to 2011, the average SWHS Chinook salmon inriver harvest was 1,182 (SE 205) fish. An unknown number of Anchor River Chinook salmon are also harvested in a mixed-stock sport troll fishery within Cook Inlet near the river mouth.

Before 2003, there were problems enumerating the Anchor River Chinook salmon escapement over the entire run. Traditional sonar methods (e.g., split-beam sonar), commonly used in large Alaskan rivers at the time (e.g., the Kenai River), were not suited for smaller streams like the Anchor River because of periodic low water conditions that are too shallow to insonify. Also, traditional weir methods (fixed picket or resistance board weirs), commonly used in small streams, could not be installed in the Anchor River in May and early June because the river is typically too high and swift at that time for installation. Therefore, an annual aerial survey was conducted during peak spawning to index and evaluate Chinook salmon escapement (Appendix A1). However, because of the inherent biases associated with the index counts (e.g., differences in survey conditions and surveyor biases), year-to-year comparisons of Chinook salmon escapement have been difficult and inconclusive.

In 2003, dual-frequency identification sonar (DIDSON) manufactured by Sound Metrics Corporation (SMC)[1] was used to monitor Chinook salmon escapement in the Anchor River (Kerkvliet et al. 2008). The DIDSON was deployed on the mainstem of the Anchor River just below the north and south forks confluence and just upstream of the fishery at a site where the river profile was relatively level (Figure 2).

The 2003 Anchor River Chinook salmon escapement (9,238 fish) was higher than expected even though the DIDSON began operating in late May after the beginning of the run and stopped operating in early July before the run had ended (Table 3). It was estimated that the measured escapement in 2003 represented about 70% of the true escapement based on the average proportion of the runs in 2004 and 2005 (2 years with similar water temperatures and flow rate patterns) that escaped over the same time period. From 2004 to 2008 and in 2010, the entire Chinook salmon escapement was estimated using the DIDSON during high discharge rates in the early spring through early to mid-June and using a resistance board weir thereafter for the rest of the season. In 2009, the DIDSON was not required because low water levels allowed for the immediate installation of the resistance board weir, which provided the first complete Anchor River Chinook salmon escapement census. Beginning in 2010, an underwater video system was incorporated into the weir and used to monitor escapement near the end of the run in early August (Kerkvliet and Booz 2018a).

Anchor River Chinook salmon escapement counts based on DIDSON counts have a negative bias because all sonar images of fish swimming upstream and downstream are assumed to be Chinook salmon even though an unknown portion of the downstream sonar images include postspawning steelhead (*Oncorhynchus mykiss*) kelts emigrating out of the river. In 2009, with the early weir installation, both emigrating kelts and immigrating Chinook salmon were monitored at the sonar-weir site (Kerkvliet and Booz 2012). The midpoint of the 2009 kelt emigration (7 June) was earlier than the midpoint of the Chinook salmon immigration (23 June). Given a typical weir installation date of early to mid-June, and assuming the timing of the 2009 kelt emigration was typical, then a large portion of the kelt emigration may occur during the DIDSON operation. Based on the census of immigrating Chinook salmon and emigrating kelts in 2009, the negative bias had the DIDSON been used would have been at most 17%. Note that this percentage is based on the lowest escapement of Chinook salmon between 2003 and 2011. A similar emigration of steelhead during the largest measured Chinook salmon run would translate to a negative bias of about 5%.

Since 2003, the annual Chinook salmon escapement in the Anchor River has ranged from 3,455 (SE 0) in 2009 to 12,016 (SE 283) in 2004 (Table 4). Inriver exploitation rates (percentage of the total run that is harvested) have ranged from less than 9.9% in 2003 to 21.7% in 2008.

The Anchor River Chinook salmon escapement goal has been refined as annual escapement data have become available (Appendix A2). In 2010, ADF&G modified the goal to a sustainable escapement goal (SEG[2]) of 3,800–10,000 Chinook salmon. The SEG was set by using the full probability spawner–recruit model described in Szarzi et al. (2007) and updated with the most

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1 Product names and manufacturers used in this publication are included for completeness but do not constitute product endorsement.

2 SEG is a level of escapement indicated by an index or estimate that is known to provide sustained yield for over a 5–10 year period (Alaska Administrative Code 5 AAC 39.223).

recent escapement and harvest through 2009 (Otis et al. 2010). The lower end of the SEG is the point estimate for maximum sustained yield and the upper bound is estimated carrying capacity. The range minimizes the risk of overfishing and allows for liberalization of the harvest when escapements are large.

Anchor River sport fishing regulations have undergone a series of changes since the early 2000s as escapement assessment improved (Appendix A3; Kerkvliet et al. 2013). Beginning in 2009, the inriver and nearby marine fisheries were restricted by emergency order (EO) in response to low Chinook salmon escapement. Despite the restrictions, the lower bound SEG of 5,000 was not achieved. In 2010, the Alaska Board of Fisheries (BOF) reduced the Anchor River annual limit to 2 Chinook salmon in combination with Deep Creek and extended the conservation zone surrounding the Anchor River mouth from 1 mile north and south to 2 miles north and south from 1 April to 30 June. The other restrictions remained unchanged: scheduled Chinook salmon sport fishery openings began on the 3-day weekend before Memorial Day weekend followed by the 4 consecutive 3-day weekends and the 5 Wednesdays following each weekend.

This report is part of a continuing series designed to evaluate the Anchor River Chinook salmon stock. The Chinook salmon escapement estimates will be used in future escapement goal analyses and also to manage the fishery according to the *Sustainable Fisheries and Escapement Goal Policy* (Alaska Administrative Code 5 AAC 39.223).

OBJECTIVES

Primary Objectives

1) Estimate the Anchor River Chinook salmon escapement that passes upstream of 2.8 RKM (about 2 river miles) from the river mouth.
2) Estimate the age and sex composition of the Chinook salmon escapement.

Secondary Objectives

1) Estimate length, age, and sex composition of the Chinook salmon escapement.
2) Examine between-reader and within-reader variation of DIDSON counts.
3) Determine seasonal and diel[3] run timing of Chinook salmon.
4) Compare daily escapement to daily river stage and temperature averages.
5) Examine all Chinook salmon video recorded and sampled for age, sex, and length (ASL) for an adipose fin.

METHODS

OPERATION DATES AND EQUIPMENT

Anchor River Chinook salmon escapement was monitored at RKM 2.8, which is approximately 0.02 RKM downstream of the north and south forks confluence (Figure 3). In 2012, the escapement was enumerated from 14 May at 1800 hours through 13 June at 1300 hours using the DIDSON (Figure 4). The DIDSON was operated at low frequency through 5 June and then at high frequency for the remainder of its operation. River conditions allowed installation and operation of the

[3] "Diel" is defined as "of or pertaining to a 24 h period."

resistance board weir fitted with a motion-detecting underwater video system on 13 June (Figure 5). The escapement was then censused from 13 June at 1400 hours through 3 August at 0500 hours using video recordings of fish passage through the weir. The weir was compromised during high water conditions from 25 June through 26 June at 1230 hours. The steelhead kelt emigration was not assessed in 2012 due to the later timing of the resistance board weir installation.

During DIDSON operation, beach seines were used to capture Chinook salmon for ASL estimation. Beach seins were used in the south fork on 7 and 14 June, and in the north fork on 29 May and 4 June. During the weir operation, ASL samples were collected from the weir live box from 13 June to 9 July; however, due to low fish passage and failure to reach sample size goals, samples were also collected downstream of the weir on 9 July using a beach seine.

DIDSON and Partial Picket Weirs

In 2012, an ultra-high resolution large lens (large lens) was used in the DIDSON. The large lens almost doubles the resolution of the standard lens and has a smaller vertical beam pattern; the resolution is also better at the longer ranges (>15 m, as needed at the Anchor River) than the standard lens. However, the highest image resolution for the large lens is still achieved when the DIDSON is operated at shorter ranges using the higher of 2 available frequencies (Burwen et al. 2007, 2010; Kerkvliet and Booz 2018a).

Because the width of the Anchor River under high water conditions at the monitoring site (about 31 m) is greater than the effective range of the DIDSON (about 20 m), a partial weir was installed on each bank to narrow the insonified corridor to 20 m or less (Figure 4). The weirs were constructed of steel A-frame structures joined together with upright PVC pickets threaded through aluminum frames. Additional frames and pickets could be added or removed as necessary due to changing water levels. The weirs were extended to narrow the insonified corridor to about 10 m. All bottom irregularities at the base of the partial weirs were sealed using sandbags that prevented fish from migrating past the DIDSON undetected.

The DIDSON was first enclosed in an SMC silt protection box, and then mounted on a “goalpost” type mount. The remote aiming unit used in previous years was unavailable in 2012, so all sonar positioning and aiming was done manually via hand-cranks built into the mount. The communication cables from the DIDSON lead to electronics inside a WeatherPort tent. DIDSON data were stored and processed on a Dell laptop computer, transferred via an external hard dive, and processed on a Dell desktop computer using Echotastic software (version 2.5). Separate computers were used for data collection and processing to avoid data corruption or interruption of recording. Use of the Echotastic software was new in 2012. To ensure data quality would be unaffected by the change in software, several files per day were read using both Echotastic and the DIDSON software (version 5.25.28) used in previous years. Files were saved every 20 minutes and designated as first, second, and third 20-minute count files. All electronics were powered by a 2000 W generator, with an inline battery backup system comprising six 100 Ah 12 V batteries run in parallel to a 600 W inverter.

The DIDSON was positioned approximately 0.5 m upstream and no less than 3 m towards the bank from the terminal end of the right bank weir (the right bank is defined as the right side of the river when facing downstream; Figure 3). The DIDSON lens was aimed slightly downward across the insonified corridor and was positioned at least 10 cm off the river bottom. The aim of the DIDSON resulted in an insonified cone to the terminal edge of the right bank weir that ensured full coverage of the migration corridor.

Resistance Board Weir

The resistance board weir (about 31 m in length) was installed approximately 6 m downstream from the DIDSON and partial weirs. Picket spacing for the resistance board weir and live boxes was approximately 2.8 cm (1.5 in) to block the passage of all but the smallest ocean-age-1 Chinook salmon (Figure 5). All bottom irregularities along the base of the resistance board weir were sealed using sandbags and a fencing skirt. The weir was visually inspected for holes daily to ensure no fish could migrate past undetected.

During June, a "steelhead chute" was formed near the thalweg by weighting the downstream end of a resistance board weir panel with a sandbag. The weight of the sandbag allowed a shallow stream of water that fish could use to swim downstream over the weir. The placement of the sandbag was used to adjust the water depth flowing over the weir panel so that it was deep enough to allow kelts to swim downstream, but shallow enough to prevent upstream migration. No counts of steelhead trout were made in 2012.

A live box was attached to the upstream edge of the weir and an underwater video system was then attached to the upstream edge of the live box, allowing fish to pass upstream 24 hours per day, 7 days per week. The live box and underwater video system was installed near the center of the river in the thalweg.

The video system consisted of a sealed aluminum box containing an underwater video camera and 2 underwater 20 W halogen lights attached to a fish passage chute (Figure 5). The system was installed on the upstream end of the live box. As fish swam through the live box, they entered the fish passage chute and passed the video camera. The camera box was attached with the glass front towards the side of the fish passage chute.

The box was constructed of 3.2 mm aluminum sheeting and had a sealed 9.5 mm thick safety glass front (this is referred to as "camera box" below). The box also had a sealed hatch on the top to allow access inside the box and a 1 m tube for running cables through the box. The box was filled with distilled water to provide a clear water lens in front of the camera for increased video quality, protection for the camera from silt, and weight to sink it. The camera was mounted on a rail in the bottom of the box with an adjustable mount and aimed through the safety glass towards the fish passage chute. The lights were mounted on rails and aimed in a way to illuminate the entire focal range of the camera throughout the day. The passage chute was roughly 1 m long by 0.4 m wide and constructed of sheet aluminum and angle bracket aluminum. The chute had a removable background and lid. The background was set to constrict the width of the fish passage chute to 15 cm but could be adjusted laterally to widen or narrow fish passage. The lid was used to prevent natural light within the fish passage chute. Both the background and lid were periodically removed to clean the glass.

The video system recorded fish passage 24 hours per day using motion detection software through a digital video recorder (DVR) capture card installed into a Dell desktop computer. All video files were recorded at 30 frames per second and written to a 3-terabyte external hard drive. The computer was installed inside the Weatherport tent and was powered with the same generator and battery system as the DIDSON. Video files of motion-detected fish images were reviewed with Watchnet software provided by the DVR capture card manufacture.

ESCAPEMENT MONITORING

DIDSON

In 2012, images of fish moving either upstream or downstream were counted for a 20-minute file for each hour the DIDSON was operated. The counts from the 20-minute file were then expanded to the hour to represent fish passage for a given hour. For quality control and to evaluate reader variability, three 20-minute files were selected each day for recounting by both the individual who had done the initial count and by a different individual.

DIDSON counts were treated as follows:

1) Images of fish moving upstream were assumed to be Chinook salmon because of migratory timing even though a very small (unknown) percentage may have been steelhead.
2) Images of fish moving downstream were assumed to be Chinook salmon. This assumption is flawed to some degree; it is known that a portion of the downstream counts include postspawning steelhead emigrating from the river. No adjustments were made to the downstream counts because it is impossible to differentiate downstream moving Chinook salmon from steelhead. This assumption can lead to an underestimation of the Chinook salmon escapement.

Resistance Board Weir

Escapement counts were tallied by hour and species as video files were reviewed. Hourly counts were summed for a daily count. No video monitoring equipment failures occurred.

Run Timing

Run timing was assessed at the weir site using cumulative daily counts. The trend in daily weir counts was also compared with the following data sets:

1) Water temperature: Recorded by datalogger every 15 minutes by Cook Inletkeeper (CIK), a citizen-based nonprofit group. The logger was installed approximately 0.1 RKM downstream of the sonar-weir site (Mauger 2013). Daily temperatures (average, minimum, and maximum) were averaged from logger readings collected every 15 minutes.
2) River stage: Recorded hourly from the gauge station (USGS 15239900) by the U.S. Geological Survey (USGS). The station is located on the south fork at approximately 11.4 RKM from the mouth of the Anchor River at a new Sterling Highway bridge.

BIOLOGICAL DATA

Over the project duration, 3 methods were used to collect biological data from Chinook salmon to assess age, sex, and length (ASL) compositions: beach seine, live box capture, and video imagery.

During DIDSON operation, ASL samples were collected from Chinook salmon captured upstream of the sonar site on the north and south forks of the Anchor River using a beach seine (30.5 m long by 2 m deep with 5.1 cm stretched mesh size). The net was fished by drifting it through deep pools (Kerkvliet et al. 2008). As water conditions allowed, a survey was conducted on each fork weekly (Table 5).

During the weir operation, ASL samples were collected from Chinook salmon as they entered the weir live box. Sampling was scheduled every other day from 1500 to 1959 hours and 0000 to

0259 hours. For each sampling event, a sample size goal was calculated by applying a sampling proportion (0.12) to the respective cumulative weir count since the last sampling event and rounding up to the nearest whole number. Because an insufficient number of Chinook salmon were captured in the live box during the sampling hours to reach the 0.12 sampling rate, additional samples were collected on 9 July downstream of the weir via netting. Throughout the weir operation, video images of external characteristics of Chinook salmon were used to determine sex.

All Chinook salmon ASL data were collected using the following 3 methods: 1) age was assessed by collecting 3 scales from each Chinook salmon from the preferred area on the fish's left side and mounting the scales to a gum card (Welander 1940), 2) sex was visually determined through external characteristics (such as kype development or a protruding ovipositor), and 3) mid eye to tail fork (METF) length was measured to the nearest 5 millimeters. The upper lobe of the caudal fin was also clipped on all Chinook salmon before release to prevent double sampling.

Scales were aged using a microfiche reader and with methods described by Welander (1940). Scales were aged without reference to size, sex, or other data. Scale samples were aged twice to estimate within-reader variability. Since 2007, the same individual has aged Anchor River Chinook salmon scales; the individual is tested annually with known aged scales (from recovered coded-wire-tagged fish). All scale samples that had conflicting ages for the 2 estimates were re-aged to produce a resolved age that was used for composition and abundance estimates.

ADIPOSE FIN INSPECTION

Each Chinook salmon captured with a beach seine, sampled from the weir live box, or observed using video recordings was inspected for the presence of an adipose fin. During ASL sampling, if a fish was found missing an adipose fin, indicating a hatchery-reared fish, it was sacrificed, and the head was sent to the ADF&G Mark, Tag, and Age Lab to identify the release site using coded wire tag (CWT) information recovered from the head. Recovered CWTs were used to validate age data.

DATA ANALYSIS

Escapement

Net DIDSON counts from 20 minute files within the *j*th hour (j = 1,...,24) of the *k*th day of the season were calculated as follows:

$$n_{jk} = u_{jk} - d_{jk} \,, \tag{1}$$

where

u_{jk} = upstream counts in hour j of day k, and

d_{jk} = downstream counts in hour j of day k.

Net upstream counts for each hour were estimated as follows:

$$\hat{c}_{jk} = \frac{60}{t_{jk}} n_{jk} \,, \tag{2}$$

where t_{jk} is the number of minutes sampled during the *j*th hour on day k (target is 20 minutes).

The following formula was used to linearly interpolate the count for hour j of day k in the rare situation where no data were available for a full hour due to computer malfunction, silting of sonar lens, etc.:

$$\hat{I}_j = C_{last} + \left[\frac{C_{next} - C_{last}}{d}\right] x_j \tag{3}$$

where

C_{last} = average of the expanded counts for the last 2 hours when counts are available,

C_{next} = average of expanded counts for next 2 hours when counts are available,

d = number of hours of missing data, and

x_j = number of hours between hour j and hour of last available count.

The number of hours for which there is no count is very small and these adjustments are not thought to contribute any meaningful bias or variance to the season-end estimates.

Hourly count estimates ($\hat{c}_{jk}$) were summed to provide daily estimates of escapement (C_k) and an estimate of the total escapement passage (C_D) during DIDSON system operation:

$$\hat{C}_k = \sum_{j=1}^{24} \hat{c}_{jk} \tag{4}$$

and

$$\hat{C}_D = \sum_{k=1}^{K} \hat{C}_k , \tag{5}$$

where K is the total number of days of operation of the DIDSON system in the year in question.

The variance of $\hat{C}_D$ was estimated as followed:

$$\mathrm{var}(\hat{C}_D) = \sum_{k=1}^{K} \mathrm{var}(\hat{C}_k) = \sum_{k=1}^{K} \sum_{j=1}^{24} \mathrm{var}(\hat{c}_{jk}) , \tag{6}$$

where

$$\mathrm{var}(\hat{c}_{jk}) = \left[\frac{60}{t_{jk}}\right]^2 \mathrm{var}(n_{jk}) = \left[\frac{60}{t_{jk}}\right]^2 s^2 \left[1 - \frac{t_{jk}}{60}\right] \tag{7}$$

and where s^2 is calculated as the successive difference estimate of variance for a systematic sample (Wolter 1985):

$$s^2 = \frac{\sum_{h=2}^{H} (n_h - n_{h-1})^2}{2(H-1)} , \tag{8}$$

where H is the total number of samples, n_h is the count of the hth sample, n_1 corresponds to the first count of the season (j = 1, k = 1), and n_H corresponds to the last count of the season (j = 24 and $k = K$).

The estimated total Chinook salmon passage over the entire season was calculated as follows:

$$\hat{C}_T = \hat{C}_D + C_W, \tag{9}$$

where C_W is the count of Chinook salmon through the weir during both SF and USFWS operation; the variance of $\hat{C}_T$ was estimated as follows:

$$\text{var}(\hat{C}_T) = \text{var}(\hat{C}_D). \tag{10}$$

Count Diagnostics

Re-counted DIDSON files provided a measure of reproducibility for escapement counts and a quality control measure. Between-reader and within-reader variability was assessed for the 2 crewmembers responsible for counting DIDSON files. Between-reader variability was assessed by comparing counts from the primary (initial counter) and secondary (re-counter) reader for three 20-minute files each day. Within-reader variability for the primary reader was assessed by comparing counts from three 20-minute DIDSON files each day (i.e., each file was read twice by a reader). Re-counted files were chosen to represent challenging counting conditions (e.g., high upstream and downstream counts and milling activity); the analysis therefore revealed worst-case scenarios of between- and within-reader variability. The following statistics were calculated for the between- and within-reader analyses:

1) Kendall's tau was calculated for each pair of counts for the same files as well as for all first and second readings. (Kendall's tau ranges from −1 to 1, representing perfect negative and positive correlation, respectively).
2) Intraclass correlation coefficient *r* was calculated for each pair of readers counting the same files (Shrout and Fleiss 1979). This statistic is a function of the correlation and agreement between counts. It ranges from 0 to 1; it is high when there is little variation between the scores given to each count. The function icc() in the R package {irr} was used with model argument set to "twoway" and type argument to "agreement."
3) A Tukey difference plot was made for the pair of readers counting the same files (Bland and Altman 1986). These plots are of differences between counts against the average of the scores of the readers.

Run Timing

Chinook salmon run timing at the sonar-weir site was described using cumulative daily counts and associated percentages. The midpoint of the Chinook salmon run was defined as the date nearest the 50% cumulative count. Diel run timing was evaluated using 24-hour DIDSON counts and video weir counts. DIDSON and video weir counts were summed over the season by hour and plotted against hour of day. The correlation of daily counts with daily river stage averages and river temperatures was also examined with Pearson's correlation coefficient (*r*) for the middle 80% of the run. The hypothesis of no correlation (r = 0) was tested.

Age and Sex Composition and Length-at-Age

Age and sex composition during the DIDSON operation was estimated from pooled samples obtained from beach seining in the north and south forks upstream of the sonar. Although statistically significant, age composition differences between the forks in 2003 and 2004 were not substantial; in 2005 and 2006, few fish were found in the north fork. Pooled beach seine samples derived from equal effort from the north and south forks is thought to be the best way to obtain a representative sample of the migration occurring during sonar operation (Kerkvliet et al. 2008).

Age and sex composition during the mainstem weir operation was estimated from systematic sampling at the weir.

The estimated proportion of Chinook salmon of age or sex class *k* (or a combination thereof), in the escapement during a given period *x* (where *x* is either *W* [Weir] or *D* [DIDSON]) was calculated as follows:

$$\hat{p}_{xk} = \frac{n_{xk}}{n_x}, \tag{11}$$

where

n_{xk} = the total number of salmon of age or sex class *k* in n_x and

n_x = the number of salmon sampled during period *x*.

The estimated proportion of Chinook salmon of age or sex class *k* (or a combination thereof) in the entire escapement to the Anchor River was calculated as follows:

$$\hat{p}_k = \phi_D \hat{p}_{Dk} + (1-\phi_D)\hat{p}_{Wk}, \tag{12}$$

where ϕ_D is the proportion of the entire escapement that migrated during the DIDSON operation (treated as a constant), and the estimated variance of proportion $\hat{p}_k$ was calculated as follows:

$$\operatorname{var}(\hat{p}_k) = \phi_D^2\left[\left(\frac{\hat{C}_D - n_D}{\hat{C}_D}\right)\frac{\hat{p}_{Dk}(1-\hat{p}_{Dk})}{n_D - 1}\right] + (1-\phi_D)^2\left(\frac{C_W - n_W}{C_W}\right)\frac{\hat{p}_{Wk}(1-\hat{p}_{Wk})}{n_W - 1}. \tag{13}$$

$\hat{C}_D$ from Equation 5 is measured with high precision and is included in the finite population correction factor in Equation 13 as a constant.

The estimated total number of Chinook salmon of age or sex class *k* was calculated as follows:

$$\hat{N}_k = \hat{C}_T \ \hat{p}_k, \tag{14}$$

where C_T is calculated in Equation 9.

The estimated variance of $\hat{N}_k$ was calculated as follows (Goodman 1960):

$$\operatorname{var}(\hat{N}_k) = \hat{C}_T^{\,2} \operatorname{var}(\hat{p}_k) + \hat{p}_k^2 \operatorname{var}(\hat{C}_T) - \operatorname{var}(\hat{p}_k)\operatorname{var}(\hat{C}_T). \tag{15}$$

Mean lengths-at-age and their variances were estimated using standard summary statistics.

The within-reader variability of Chinook salmon scale age estimates was calculated using a coefficient of variation (CV) expressed as the ratio of the standard deviation over the mean age (Campana 2001):

$$CV_j = 100\% \times \frac{\sqrt{\sum_{i=1}^{R} \frac{(X_{ij} - X_j)^2}{R-1}}}{X_j} \tag{16}$$

where

X_{ij} = the ith age estimate of the jth fish,

X_j = the mean age estimate of the jth fish, and

R = the number of times each fish is aged.

RESULTS

ESCAPEMENT

The estimated 2012 Anchor River Chinook salmon escapement of 4,509 (SE 100) fish was within the SEG range of 3,800–10,000 fish (Table 4, Appendix B1). The escapement was based on expanded sonar counts (2,247 fish, SE 100) and weir counts (2,262 fish).

The DIDSON portion of the escapement was based on 1,058 upstream and 309 downstream counts (Appendix C1). During DIDSON operation, the ratio of upstream to downstream moving fish averaged 3.4:1. The weir was compromised overnight on 25 June by high water (Appendix D1) and an unknown number of Chinook salmon passed upstream undetected. After repairs, the weir was made fish tight by 26 June at 1230 hours.

Only Chinook salmon and steelhead were captured during netting in late May and June when the DIDSON was used to monitor escapement. In May and June, Chinook salmon accounted for approximately 93% of the catch (Table 5). No adjustments were made to the upstream DIDSON counts based on the netting composition. During the July 9 netting event, Chinook salmon accounted for approximately 51% of the catch and Dolly Varden accounted for the remainder. Most (91%) of the Dolly Varden were captured near the section of the river influenced by tidal changes.

COUNT DIAGNOSTICS

Between-reader variability was evaluated for 87 DIDSON files (Table 6). The correlation (Kendall's tau) between the primary readers (A and B) was 0.92. Intraclass correlation was also high (r = 0.98). Percent agreement was 74.7%. Tukey difference plots indicated no discernible pattern for disagreements (Figure 6). Differences in counts between the pair of readers are also shown in Table 6.

Within-reader variability was also evaluated for 87 DIDSON files (Table 6). Only primary readers A and B were assessed. Correlations (Kendall's Tau) for primary readers were 0.97 (reader A) and 0.94 (reader B). Intraclass correlations were 0.99 (reader A) and 0.98 (reader B). Percent agreements were 83.3% (reader A) and 86.1% (reader B). Tukey difference plots indicated no discernible pattern for disagreements (Figure 7). Differences in counts within specific readers are also shown in Table 6.

RUN TIMING

The midpoint of the Anchor River Chinook salmon run was 13 June (Figure 8, Appendix B1). The middle 80% of the run was counted from 31 May to 22 July (53 days). Of the total 2012 escapement, 30% (1,373/4,509) was counted from 1 July to 31 July; only 11% (476/4509) were counted from 1 July to 15 July.

During the DIDSON operation, a disproportionate number of the upstream and downstream counts (about 49% and 32%, respectively) were counted from 0100 hours to 0559 hours (Figure 9). Peak upstream counts occurred at 0300 hours. Peak downstream counts occurred at 0400 hours.

During the video weir operation, a similar but more extreme pattern was found compared to that observed for the DIDSON period: a majority (about 55%) of the Chinook salmon was counted between 0100 to 0559 hours, and peak counts occurred from 0100 to 0359 hours (Figure 10).

During the middle 80% of the Chinook salmon run, daily counts were positively correlated with average river stage ($r = 0.33$, df = 51, $P = 0.016$; Figure 11) and negatively correlated with average river temperature ($r = -0.23$, df = 51, $P = 0.092$; Figure 12). Average water temperature was negatively correlated ($r = -0.71$, df = 51, $P < 0.0001$) with average river stage. During the middle 80% of the run, river stage averaged 44.3 cm (ranged from 26.8 cm to 73.1 cm; Appendix D1) and river temperature averaged 10.5°C (ranged from 5.1°C to 15.1°C; Appendix D2).

BIOLOGICAL DATA

There were 236 Chinook salmon sampled for ASL analysis (131 netting and 105 weir samples) of which 199 had readable scales. Of the 126 samples collected during netting, 64 were collected during the DIDSON period and 67 were collected downstream of the weir on July 9 (Table 5). The coefficient of variation (Equation 15) of all age estimates from Chinook salmon scales was 1.50%.

Ocean-age-3 was the dominant age class (50.4%, SE 4.0%) for the 2012 Anchor River Chinook salmon escapement (Table 7). Ocean-age-2 was the dominant age class for males (30.8%, SE 3.7%), whereas ocean-age-3 was the dominant age class for females (30.6%, SE 3.7%). Lengths from mid eye to tail fork (METF) were different between males and females ($P = 0.02$) for ocean-age-2 fish, but no difference was detected in length between males and females for ocean-age-3 fish ($P = 0.92$) and ocean-age-4 fish ($P = 0.37$). The overall mean length of males (603 mm, SE 15) was different to that of females (755 mm, SE 7; $P < 0.001$).

The sex of 2,377 Chinook salmon was determined using video images ($n = 2{,}249$) and netting samples ($n = 128$). The estimated overall male to female ratio was 1.86:1. The male to female ratio at the weir, based on video images only, was 1.5:1. The ratio based on netting during weir operation (9th July) was 2:1. These ratios are not statistically different ($\chi^2 = 1.02$, df = 1, $P = 0.31$). There was also no significant difference between the sex composition during the DIDSON (ratio of 2.4) and weir (ratio of 1.5) periods of operation ($\chi^2 = 2.12$, df = 1, $P = 0.145$) or between populations sampled by netting (ratio of 2.2) and by the weir (ratio of 1.5; $\chi^2 = 3.4$, df = 1, $P = 0.067$). Furthermore, no significant difference in sex composition ($\chi^2 = 0.16$, df = 1, $P = 0.6849$) was detected between the north and south forks (ratio of 2.4) and the population sampled with nets in the mainstem downstream of the weir (ratio of 2).

ADIPOSE FIN INSPECTION

No hatchery strays were detected based on the presence of an adipose fin on all 131 Chinook salmon captured during netting. Of the 2,262 Chinook salmon observed from video files, 2 Chinook salmon with missing adipose fins (indicating hatchery-reared fish) were observed from video footage.

DISCUSSION

The 2012 Chinook salmon estimated escapement of 4,509 fish was within the sustainable escapement goal (SEG) range (3,800–10,000) and was the fourth lowest since 2003 (Table 4). Although the escapement fell within SEG, the overall run size was below average. Anchor River Chinook salmon harvest opportunity was limited due to EO restrictions and poor water conditions during the sport fishery openings in late May. The SWHS harvest estimate for Anchor River Chinook salmon was 38 (SE 23) with an estimated exploitation of 0.8%. In 2012, a preseason EO restricted the fishery by closing the 5 Wednesday openings and by extending the closed area downstream of the Anchor River sonar-weir site by 1,000 feet to protect holding Chinook salmon. During the first 2 Anchor River openings (19–21 May and 26–28 May) harvest was probably low because of high water. Starting the third weekend opening (2–4 June), as water levels began dropping and fishing conditions improved, gear was restricted to 1 unbaited, single-hook artificial lure, but catch rates remained low. The Anchor River was closed to sport fishing for the fourth (9–11 June) and fifth (16–18 June) weekend openings, and from 1 to 15 July. These closures were issued in concert with a series of sport fishing restrictions in the adjacent marine waters from north of Bluff Point to the mouth of the Ninilchik River.

The run timing of the 2012 run was similar to the timing of smaller size runs since 2009; run timing of the larger size runs (2004–2008) were earlier (Figure 8). The 2012 run size (4,547 fish) was close to the size of the 2010 run (Table 4); however, exploitation was much lower in 2012. The lower 2012 exploitation (Table 4) can be attributed to the more restrictive 2012 fishery and higher river levels during the May and June openings.

The underwater video system proved a very effective method for monitoring Anchor River Chinook salmon. It allowed fish to pass naturally through the weir 24 hours per day and has substantially reduced the workload of technicians. However, using the video weir live box to capture Chinook salmon for ASL sampling has proven problematic because fish do not tend to build up below the weir and in the live box. Collecting ASL samples using nets downstream of the weir in 2012 proved to be a more effective option to live-box sampling. It is recommended that future ASL sampling should be done downstream of the weir site when possible until Dolly Varden begin to enter the river in high numbers after 15 July, which is just before peak spawning of Chinook salmon.

The return of ocean-age-4 Chinook salmon in 2012 marked the final adult return from brood year (BY) 2006 and the third year that production could be fully assessed. The return (3,961 fish) from the 2006 escapement (8,945 fish, SE 290) was below 1:1 replacement (Tables 8 and 9). Although the 2006 escapement is below 10,000 fish, which is the carrying capacity based on the current full probability model used to establish the SEG (Szarzi et al. 2007), the BY 2006 production (total return) was about 500 fish above the BY 2004 production and about 1,000 fish below the BY 2005 production. The escapements for 2004 and 2005 were above 10,000 fish. It is expected that with additional years of production data, the low production of BYs 2004–2006 can be more thoroughly evaluated by comparing production from contrasting low and high escapements.

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TABLES

Table 1.–Drainage characteristics of the north and south forks of Anchor River.

	Anchor River		
Drainage characteristics	North fork	South fork	Total
Watershed area (km^2)	181.5	405.3	586.8
Wetland area (km^2)	92.9	189.0	281.9
Percent wetland	51.2	46.6	48.0
Stream length (RKM)	149	352	501
Anadromous stream length (RKM)	90	176	266

Source: S. Baird, Research Analyst, Kachemak Bay Research Reserve in Homer, AK, unpublished data, 2006.
Note: "RKM" means river kilometers.

Table 2.–Statewide Harvest Survey estimates of Chinook salmon harvest and catch and number of days open to harvest for Anchor River Chinook salmon, 1977–2012.

	Chinook salmon				Chinook salmon openings				
	Harvest		Catch [a]		Weekend days [a]			Harvest	
Year	Estimate	SE	Estimate	SE	Before MD [b]	On and after MD [c]	Wednesdays	Total days [d]	Harvest per day
1977	1,077	–	NA	–	0	8	0	8	135
1978	2,109	–	NA	–	0	12	0	12	176
1979	1,913	–	NA	–	0	12	0	12	159
1980	605	–	NA	–	0	12	0	12	50
1981	1,069	–	NA	–	0	12	0	12	89
1982	718	–	NA	–	0	12	0	12	60
1983	1,269	–	NA	–	0	12	0	12	106
1984	998	–	NA	–	0	12	0	12	83
1985	672	–	NA	–	0	12	0	12	56
1986	1,098	–	NA	–	0	12	0	12	92
1987	761	–	NA	–	0	12	0	12	63
1988	976	–	NA	–	0	15	0	15	65
1989	578	–	NA	–	0	15	0	15	39
1990	1,479	–	4,119	–	0	15	0	15	99
1991	1,047	–	2,540	–	0	15	0	15	70
1992	1,685	–	4,506	–	0	15	0	15	112
1993	2,787	–	6,022	–	0	15	0	15	186
1994	2,478	–	3,890	–	0	15	0	15	165
1995	1,475	–	3,545	–	0	15	0	15	98
1996	1,483	201	6,594	1,883	0	15	0	15	99
1997	1,563	186	5,289	1,072	0	15	0	15	104
1998	783	119	2,443	361	0	15	0	15	52
1999	1,409	192	6,903	1,769	0	15	0	15	94
2000	1,730	193	5,200	797	0	15	0	15	115
2001	889	162	2,415	452	0	15	0	15	59
2002	1,047	192	4,103	854	0	12	0	12	87
2003	1,011	157	4,311	792	0	12	0	12	84
2004	1,561	198	5,561	1,214	0	15	0	15	104
2005	1,432	233	5,028	1,386	3	12	0	15	95
2006	1,394	197	4,638	1,011	3	12	0	15	93
2007	2,081	326	9,792	1,812	3	12	0	15	139
2008	1,486	241	3,245	542	3	12	5	20	74
2009	737	212	2,296	518	3	6	3	12	61
2010	364	118	889	287	3	6	3	12	30
2011	573	163	1,227	497	3	6	3	12	48
2012	38	23	189	89	3	6	0	9	4
Average									
2003–2011	1,182	205	4,110	–	2	10	2	14	81
1977–2011	1,267	193	4,298 [e]	–	1	13	0	14	93

Source: Alaska Sport Fishing Survey database [Internet]. 1996–present. Anchorage, AK: Alaska Department of Fish and Game, Division of Sport Fish (cited August 2015). Available from: http://www.adfg.alaska.gov/sf/sportfishingsurvey/.

Note: “Harvest” is number of fish kept, “catch” is fish harvested plus released, “NA” means not applicable, and the en dash means not calculated.

[a] Weekend openings consisted of Saturday and Sunday from 1977 to 1987 and Saturday–Monday since 1988.

[b] Before the Memorial Day weekend.

[c] On and after the Memorial Day weekend.

[d] Days open for Chinook salmon harvest (regulatory openings adjusted by emergency orders as needed).

[e] Average for 1990–2011.

Table 3.–Anchor River weir and DIDSON fish counts by species, 1987–1995 and 2003–2012.

				Fish counts						
Year	Project dates	Location (RKM) [a]	Method	Chinook salmon [b]	Dolly Varden [c]	Pink salmon [c]	Chum salmon	Sockeye salmon	Coho salmon [d]	Rainbow trout or steelhead [e]
1987 [f]	04 Jul–10 Sep	1.6	fixed picket weir	204	19,062	2,084	19	33	2,409	136
1988 [f]	03 Jul–05 Oct	1.6	fixed picket weir	245	14,935	777	24	30	2,805	878
1989 [f]	06 Jul–05 Nov	1.6	resistance board weir	95	11,384	4,729	165	212	20,187	769
1990 [f]	04 Jul–15 Aug	1.6	resistance board weir	144	10,427	355	17	39	190	3
1991 [f]	04 Jul–15 Aug	1.6	resistance board weir	39	18,002	1,757	9	46	13	5
1992 [f]	04 Jul–01 Oct	1.6	resistance board weir	129	10,051	992	39	174	4,596	1,261
1993 [f]	03 Jul–16 Aug	1.6	resistance board weir	90	8,262	1,019	12	71	290	1
1994 [f]	03 Jul–16 Aug	1.6	resistance board weir	111	17,259	723	2	61	420	1
1995 [f]	04 Jul–12 Aug	1.6	resistance board weir	112	10,994	1,094	4	73	725	10
2003 [g]	30 May–09 Jul	2.8	DIDSON	9,238 [h]	–	–	–	–	–	–
2004 [g]	15 May–13 Sep	2.8	DIDSON, resistance board weir	12,016 [h,i]	7,846	1,079	79	45	5,728	20
2005 [g]	13 May–09 Sep	2.8	DIDSON, resistance board weir	11,156 [h,i]	5,719	4,916	146	319	18,977	107
2006 [g, j]	15 May–24 Aug	2.8	DIDSON, resistance board weir	8,945 [h,i]	234	954	45	38	10,181 [j]	4
2007 [g]	14 May–12 Sep	2.8	DIDSON, resistance board weir	9,622 [h,i]	1,309	3,916	156	200	8,226	325
2008	13 May–11 Sep	2.8	DIDSON, resistance board weir	5,806 [h,i]	1,344	2,017	66	52	5,951	258
2009	12 May–11 Sep	2.8	resistance board weir	3,455	1,404	4,975	68	62	2,692	54
2010	13 May–29 Sep	2.8	DIDSON, resistance board weir	4,449 [h,i]	1,352	972	67	212	6,014	586
2011	13 May–21 Sep	2.8	DIDSON, resistance board weir	3,545 [h,i]	1,523	2,169	60	47	1,866	132
2012	14 May–3 Aug	2.8	DIDSON, resistance board weir	4,509 [h,i]	2,125	321	27	6	32	1

-continued-

[a] River kilometers (RKM) from mouth of the Anchor River.

[b] Chinook salmon counts represent escapement because there is no harvest above the monitoring site. The run was only partially counted in 1987–1995 due to weir operation dates and location, and in 2003 due to weir operation dates.

[c] Incomplete Dolly Varden–pink salmon counts due to picket spacing of the weir (2004–2008) because smaller fish were able to pass through the weir pickets undetected.

[d] Incomplete coho salmon counts because the project operation dates did not span entire run (1991, 1993–1995, 2005–2006, 2012).

[e] Counts beginning July 1 through end of weir operation. Incomplete counts due to project operation dates and weir location (1987, 1990–1991, 1993–1995, and 2004–2009, 2012).

[f] Source for 1987: Larson et al. (1988); 1988: Larson and Balland (1989); 1989: Larson (1990); 1990: Larson (1991); 1991: Larson (1992); 1992: Larson (1993); 1993: Larson (1994); 1994: Larson (1995); 1995: Larson (1997), when escapement weir was located approximately 1.6 RKM from mouth.

[g] Source for 2003–2004: Kerkvliet et al. (2008); 2005–2006: Kerkvliet and Burwen (2010); 2007–2008: Kerkvliet et al. (2012); 2009: Kerkvliet and Booz (2012). 2010–2011: Kerkvliet and Booz (2018a, 2018b).

[h] All DIDSON images and the associated counts were assumed to be Chinook salmon.

[i] Chinook salmon estimates based on combined DIDSON and weir census. If DIDSON was operated in July, counts were apportioned between large fish (Chinook salmon) and small fish (Dolly Varden and pink salmon).

[j] No counts were collected from 19 to 21 August because the weir washed out due to flooding. The DIDSON was operated again from 22 to 24 August; an estimated 3,292 coho salmon were counted.

Table 4.–Anchor River Chinook salmon escapement, freshwater harvest, total run, and exploitation estimates, 2003–2012.

			Chinook salmon					
			Escapement		Inriver harvest		Total inriver run [b]	
Year	Escapement goal [a]	Project dates	Estimate	SE	Estimate	SE	Estimate	Exploitation rate
2003	750–1,500	May 30–Jul 09	9,238 [c]	0	1,011	157	10,249	9.9 [d]
2004	750–1,500	May 15–Sep 15	12,016 [e]	283	1,561	198	13,577	11.5
2005	No goal	May 13–Sep 09	11,156 [e]	229	1,432	233	12,588	11.4
2006	No goal	May 15–Aug 24	8,945 [e]	289	1,394	197	10,339	13.5
2007	No goal	May 14–Sep 12	9,622 [e]	238	2,081	326	11,703	17.8
2008	5,000	May 13–Sep 12	5,806 [e]	169	1,612	241	7,418	21.7
2009	5,000	May 12–Sep 11	3,455 [f]	0	737	212	4,192	17.6
2010	5,000	May 13–Sep 29	4,449 [e]	103	364	118	4,813	7.6
2011	3,800–10,000	May 13–Sep 21	3,545 [e]	0	573	163	4,118	13.9
2012	3,800–10,000	May 14–Aug 3	4,509 [e]	100	38	100	4,547	0.8
Average								
2009–2012			3,990		428		4,418	10.0
2003–2012			7,274		1,080		8,354	12.6

Source: Harvest estimates from Alaska Sport Fishing Survey database [Internet]. 1996–. Anchorage, AK: Alaska Department of Fish and Game, Division of Sport Fish (cited August 2015). Available from: http://www.adfg.alaska.gov/sf/sportfishingsurvey/.

[a] Sustainable escapement goal (SEG) used to manage the fishery. The 2003 and 2004 SEG based on aerial index count (Otis and Hasbrouck 2004). The 2008–2012 SEG is based on a Ricker recruitment model (Szarzi et al. 2007; Otis et al. 2010).

[b] "Total inriver run" is escapement plus freshwater harvest; total does not account for the marine harvest.

[c] Estimate is based on a census of all DIDSON files. Escapement was not fully assessed due to operation dates not spanning the entire run.

[d] Exploitation is conservative because escapement was not fully enumerated.

[e] Estimate is based on expanded DIDSON counts and weir counts.

[f] Escapement is based on weir counts.

Table 5.–Species composition of beach seine catches on the north and south forks of the Anchor River, 2012.

South fork				North fork				Mainstem			
Sample date	Chinook salmon	Steelhead	Dolly Varden	Sample dates	Chinook salmon	Steelhead	Dolly Varden	Sample dates	Chinook salmon	Steelhead	Dolly Varden
7 Jun	17	3	0	29 May	2	0	0	9 Jul	67	0	65
14 Jun	33	1	0	4 Jun [a]	12	1	0				
Total	50	4	0		14	1	0		67	0	65

[a] Of the 12 Chinook salmon captured, biological data was not collected from 4 Chinook salmon.

Table 6.–Between- and within-reader correlation analysis for DIDSON counts, Anchor River, 2012.

			Accumulated counts					
	Reader combination	Number of files	First reader	Second reader	Kendall's tau	Intraclass correlation (*r*)	Intraclass 95% CI	Percent agreement
Between reader	A and B	87	159	173	0.92	0.98	0.963, 0.984	74.7
Within reader	A and A	45	96	98	0.97	0.99	0.982, 0.993	83.3
	B and B	42	74	75	0.94	0.98	0.966, 0.988	86.1
	Overall	87	170	173	0.95	0.98	0.977, 0.989	85.2

Table 7.–The estimated ocean age, sex, and length composition of the Anchor River Chinook salmon escapement, 2012.

Sex	Parameter	Composition by ocean age [a] 1	2	3	4	Total	Composition by sex [b]
Female							
	Female samples	0	10	63	3	76	935
	Estimated percent	0	3.4	30.6	1.6		35.0
	SE percent	0	1.1	3.7	1.1		3.0
	Estimated abundance	NA	153	1,380	72		1,578
	SE abundance	NA	50	170	50		140
	Length samples	NA	10	63	3		89
	Mean length (mm)	NA	642	771	825		755
	SE mean length (mm)	NA	22	6	20		7
Male							
	Male samples	21	62	35	5	123	1,442
	Estimated percent	10.8	30.8	19.8	2.9		65
	SE percent	2.5	3.7	3.3	1.4		3.0
	Estimated abundance	487	1,389	893	131		2,931
	SE abundance	113	170	150	63		150
	Length samples	21	62	35	5		144
	Mean length (mm)	341	587	770	880		603
	SE mean length (mm)	4	7	8	58		15
Female and male							
	Combined samples	21	72	98	8	199	2,377
	Estimated percent	10.8	34.3	50.4	4.5		
	SE percent	2.5	3.8	4.0	1.8		
	Estimated abundance	487	1,547	2,273	203		4,509
	SE abundance	113	175	187	81		288
	Length samples	9	141	116	16		233
	Mean length (mm)	341	592	771	861		656
	SE mean length (mm)	4	7	5	36		12

Note: "NA" means not available.

[a] Age and length-at-age compositions are based on pooled samples collected from nets on the south and north forks, on the mainstem downstream of the weir, and the mainstem weir.

[b] Sex composition is based on pooled samples collected from nets on the mainstem downstream of the weir, on the south and north forks, and the mainstem weir.

Table 8.–Anchor River Chinook salmon estimated escapement and freshwater harvest by ocean-age composition, 2003–2012.

	Escapement										Freshwater harvest					
											Number of fish					
			Percent by ocean age				Number of fish by ocean age						Ocean age			
Run year	Estimate	SE	1	2	3	4	1	2	3	4	Estimate	SE	1	2	3	4
2003 [a]	9,238	0	5.1	23.0	57.8	13.8	471	2,125	5,340	1,275	1,011	157	52	233	584	140
2004	12,016	283	8.8	20.7	48.6	21.9	1,057	2,487	5,840	2,632	1,561	198	137	323	759	342
2005	11,156	229	5.0	23.9	52.2	18.9	558	2,666	5,823	2,108	1,432	233	72	342	748	271
2006	8,945	289	6.4	16.5	52.1	25.0	572	1,476	4,660	2,236	1,394	197	89	230	726	349
2007	9,622	238	0.5	22.0	53.4	24.1	48	2,116	5,138	2,319	2,081	326	10	458	1,111	502
2008	5,806	169	4.4	21.8	68.5	5.2	255	1,266	3,977	302	1,612	241	71	351	1,104	84
2009	3,455	0	7.8	51.1	36.7	4.4	269	1,766	1,268	152	737	212	57	377	270	32
2010	4,449	103	7.0	36.1	51.3	5.6	311	1,606	2,282	249	364	118	25	131	187	20
2011	3,545	0	3.2	50.0	41.1	5.7	113	1,773	1,457	202	573	163	18	287	236	33
2012	4,509	100	10.8	34.3	50.4	4.5	487	1,547	2,273	203	38	0	4	13	19	2
Average 2003–2012	7,274	141	5.9	29.9	51.2	12.9	414	1,883	3,806	1,168	1,080	185	54	274	574	177

[a] Escapement was not fully assessed due to operation dates.

Table 9.–Anchor River Chinook salmon estimated return per spawner by brood year, 2003–2012.

	Number of fish returning by brood year			
Brood year	Escapement by brood year	Freshwater harvest	Total return	Return per spawner [a]
2003	6,817	1,684	8,501	0.92 [b]
2004	2,831	653	3,484	0.29
2005	4,505	667	5,172	0.46
2006	3,535	426	3,961	0.44
2007	NA	NA	NA	NA
2008	NA	NA	NA	NA
2009	NA	NA	NA	NA
2010	NA	NA	NA	NA
2011	NA	NA	NA	NA
2012	NA	NA	NA	NA

Note: "NA" means not available.

[a] See Table 8 for estimates of total number of spawners (escapement) used to calculate return per spawner for each brood year.

[b] Positively biased estimate because escapement was not fully assessed.

FIGURES

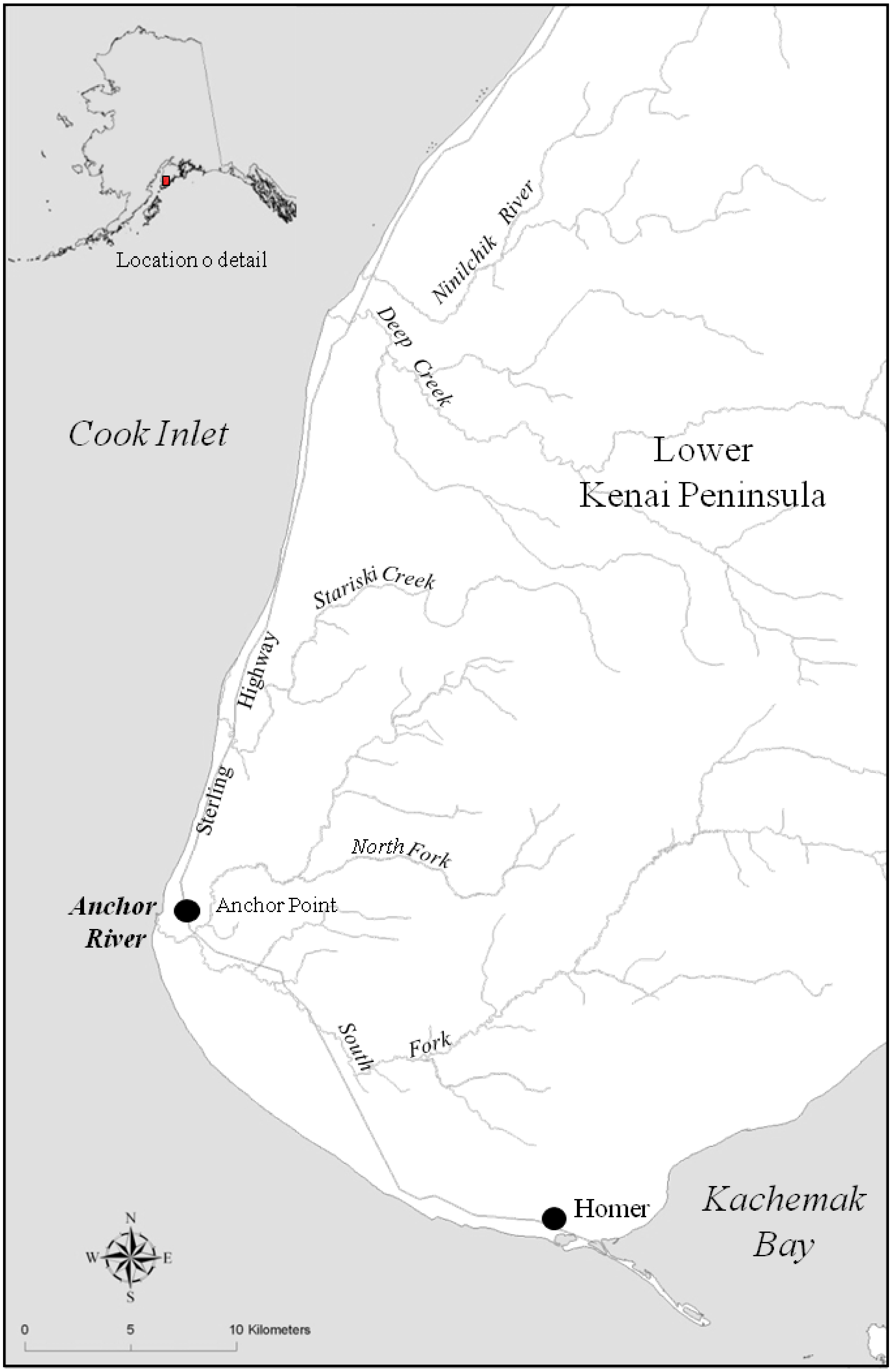

Figure 1.–Location of Anchor River and other roadside tributaries in the Lower Cook Inlet Management Area.

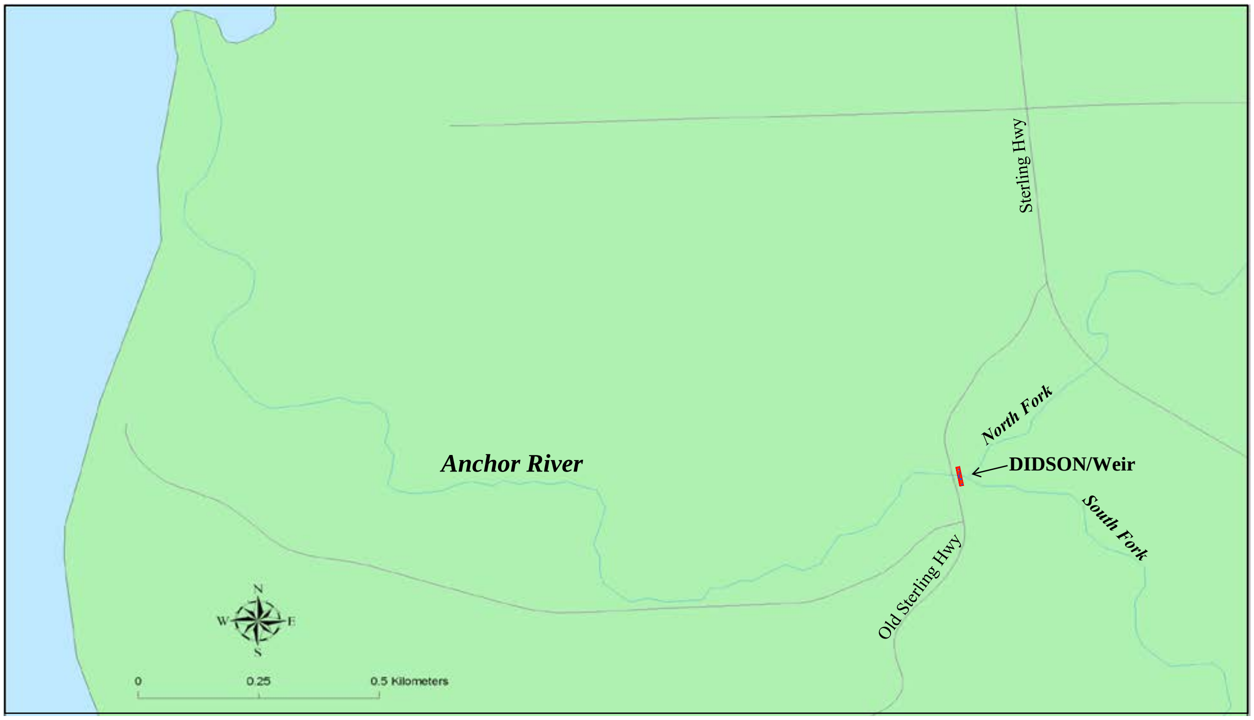

Figure 2.–Location of the mainstem DIDSON weir site on the Anchor River (lat 59.772233, long −151.835033).

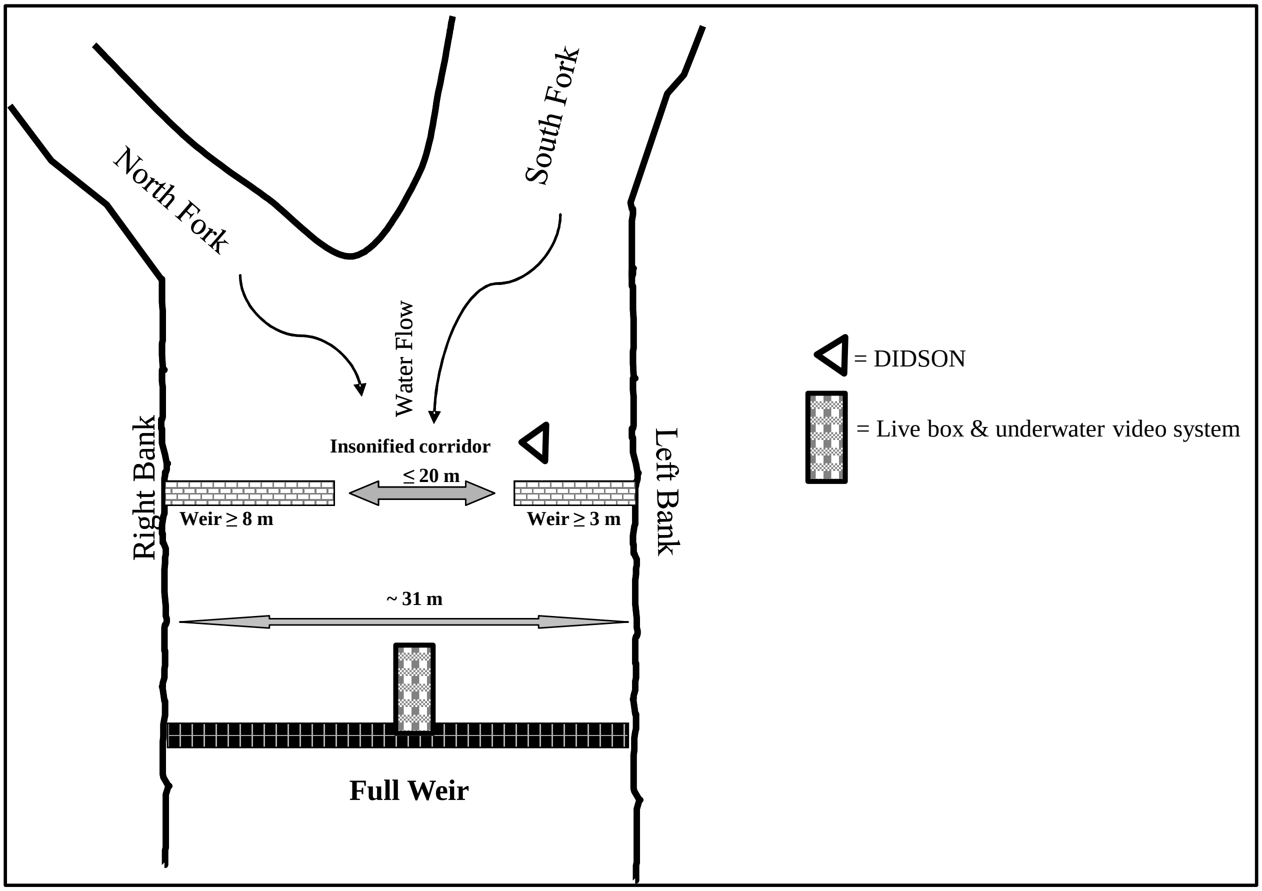

Figure 3.–Locations of the mainstem DIDSON, partial weirs, and full weir site on the mainstem of the Anchor River.

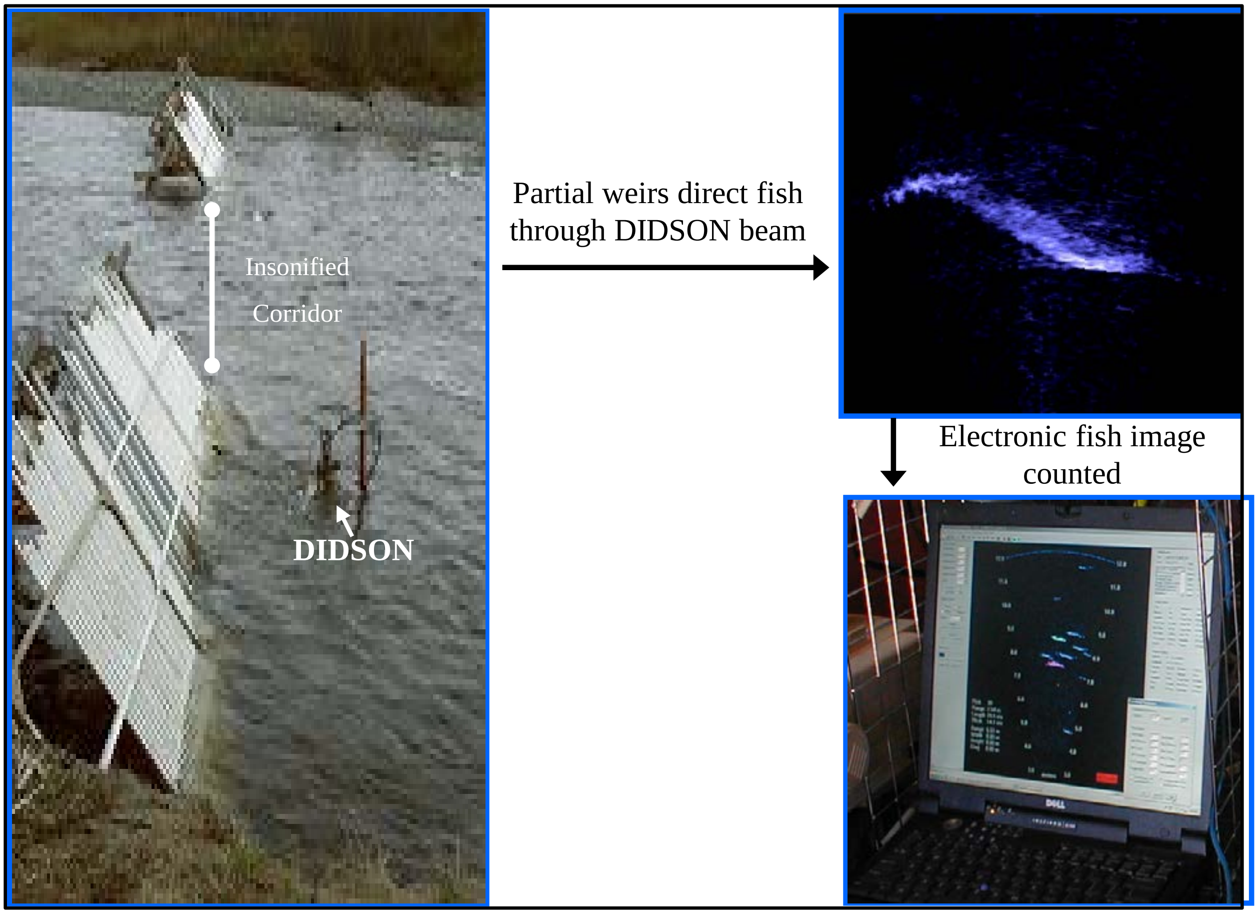

Figure 4.–DIDSON is used with partial weirs to funnel fish through the DIDSON beam.

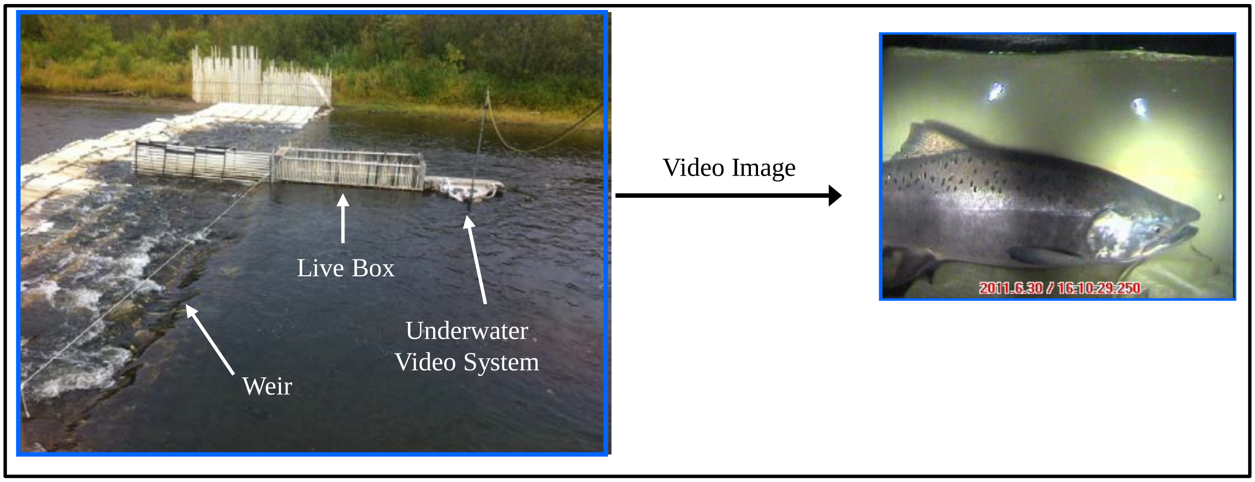

Figure 5.–Resistance board weir with midchannel live box and underwater video system on the Anchor River, 2012.

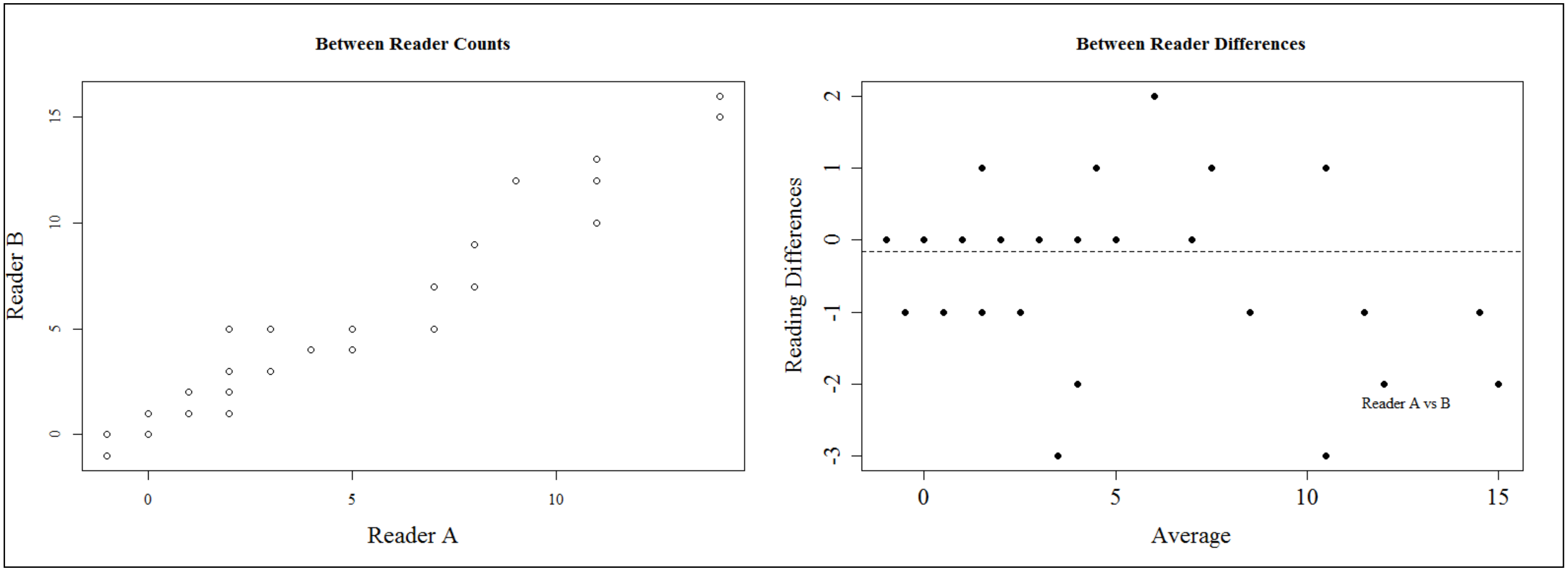

Figure 6.–Between-reader counts (left) and Tukey difference plots (right) for readers of selected DIDSON files, Anchor River, 2012.

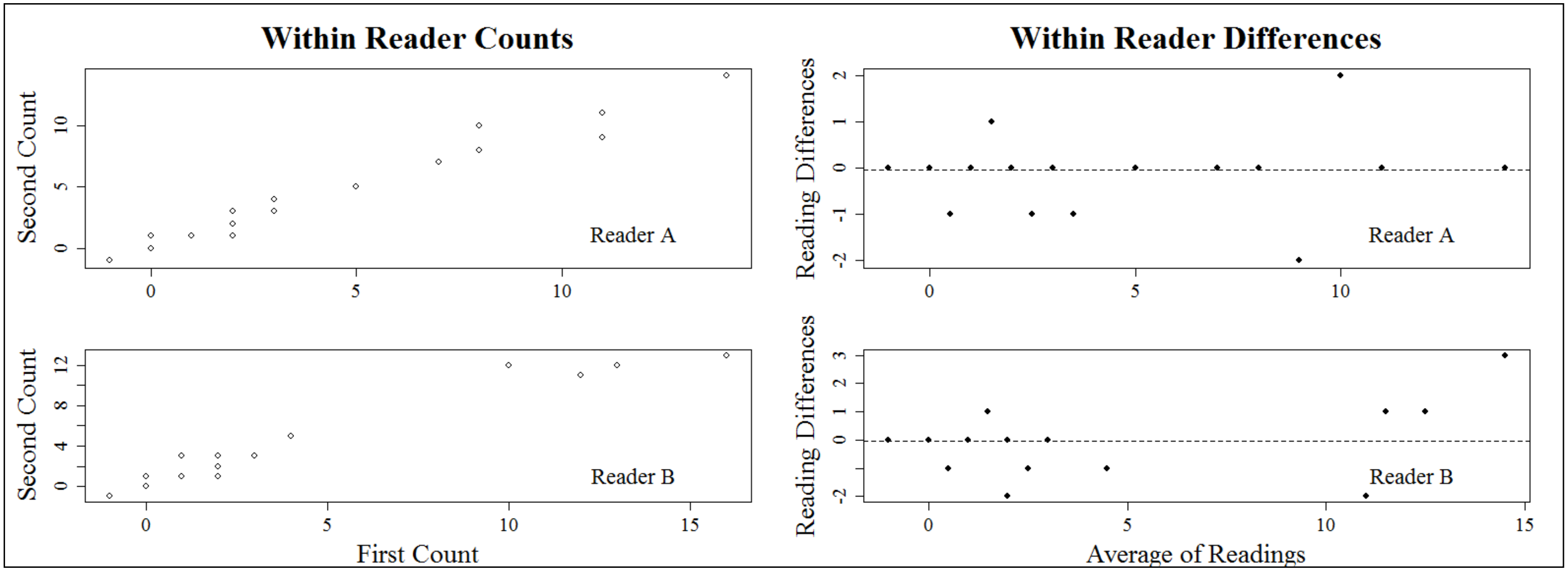

Figure 7.–Within-reader counts (left) and Tukey difference plots (right) for readers of selected DIDSON files, Anchor River, 2012

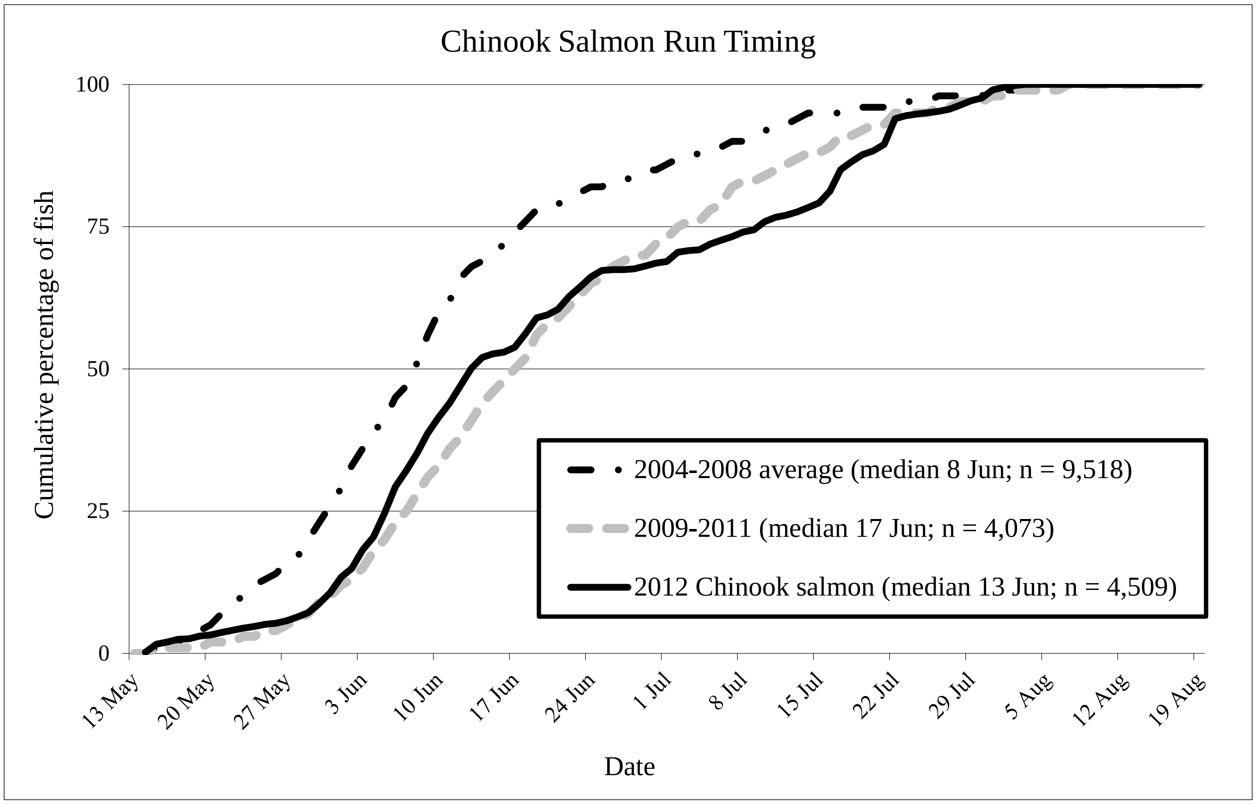

Figure 8.–Chinook salmon run timing of the 2012 immigration compared to the 2004–2008 and 2009–2011 averages at the mainstem sonar-weir site.

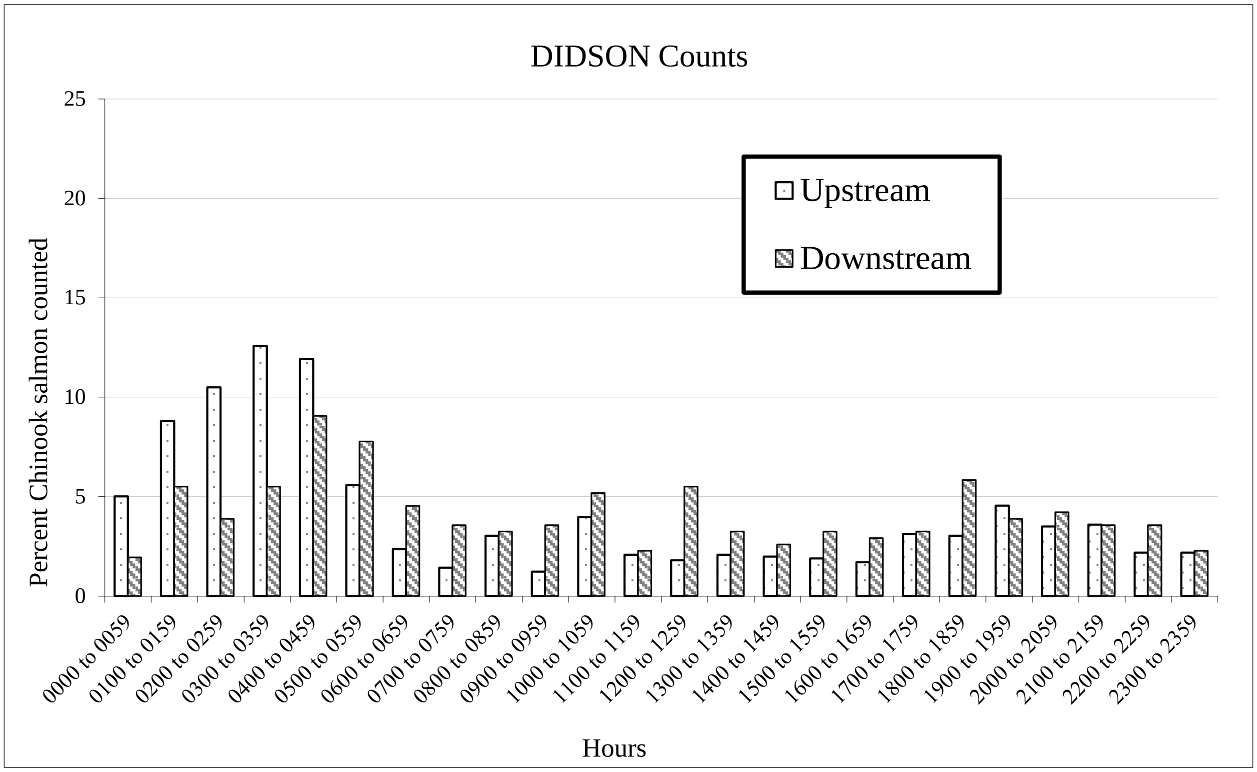

Figure 9.–Percent of all upstream and downstream images counted by hour during 14 May through 13 June based on DIDSON counts, 2012.

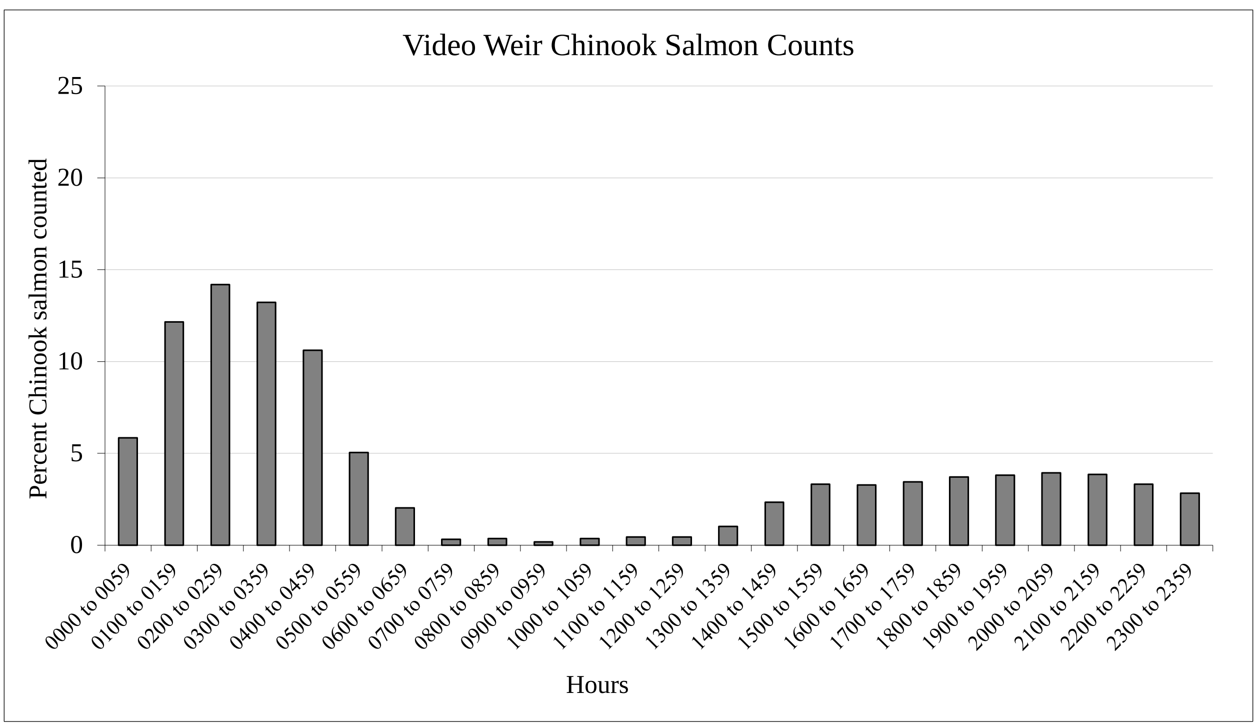

Figure 10.–Percent of Chinook salmon counted from the video weir by hour during 13 June through 3 August 2012.

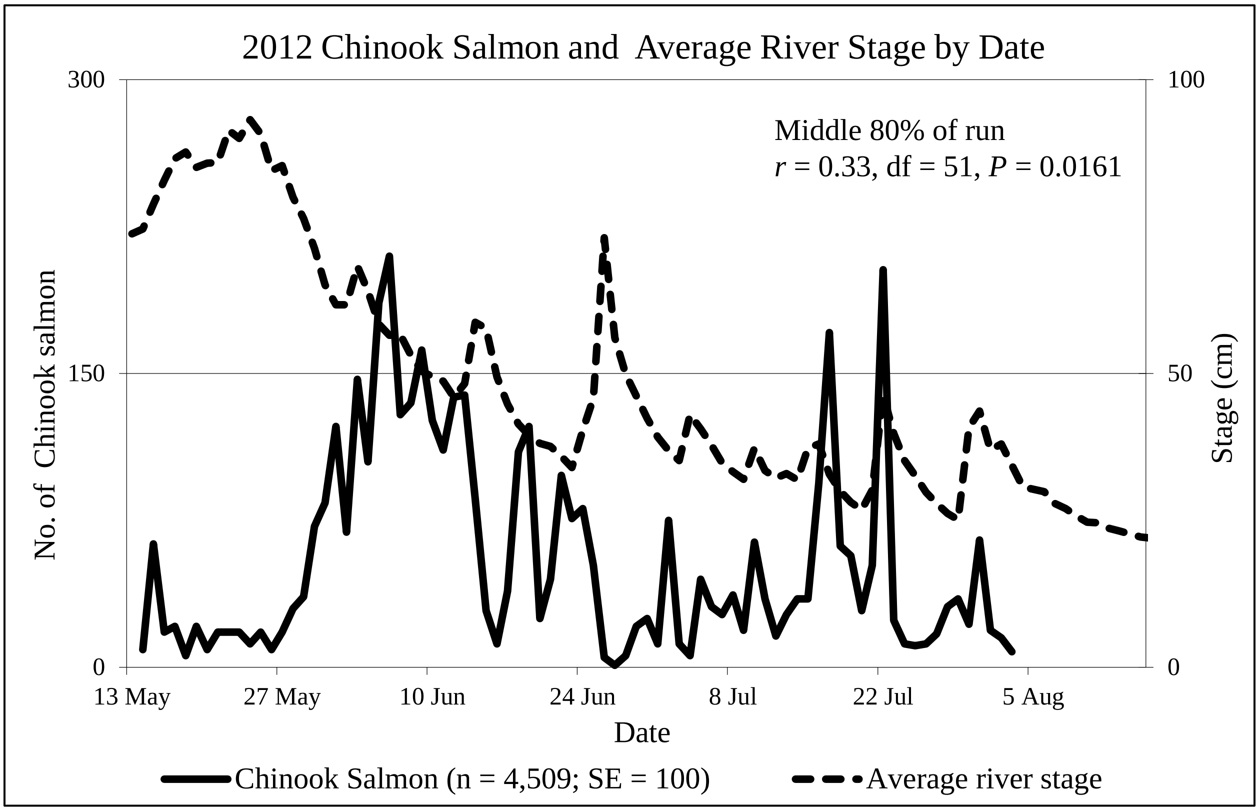

Figure 11.–Estimated daily counts of Chinook salmon at the sonar-weir site plotted against daily river stage averages, Anchor River, 2012.

Note: Stage data collected at gauge station USGS 15239900 located at approximately 11.4 RKM on the south fork, Anchor River.

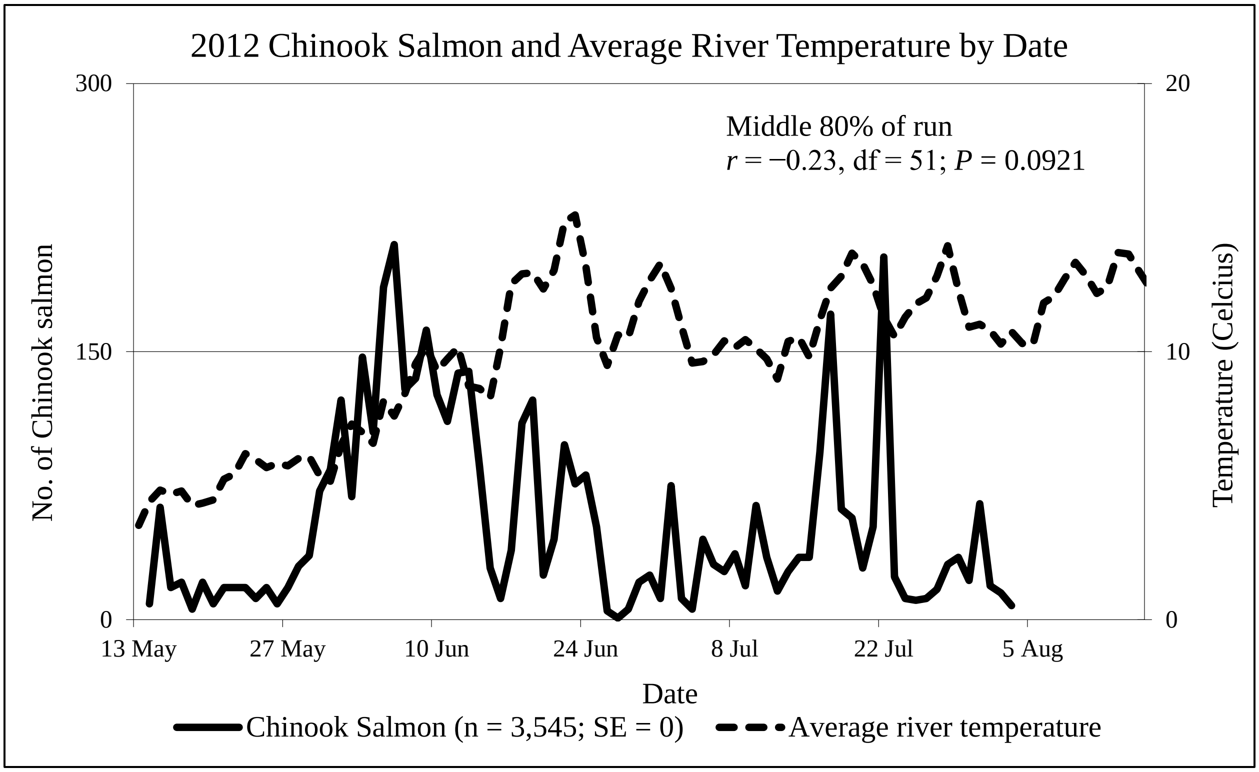

Figure 12.–Daily counts of Chinook salmon at the sonar-weir site plotted against daily river temperature averages, Anchor River, 2012.

Note: Temperature data collected approximately 0.1 RKM downstream of the south and north forks confluence of the Anchor River.

APPENDIX A: MONITORING TIMELINES FOR ANCHOR RIVER CHINOOK SALMON

Appendix A1.–Timeline of escapement monitoring for Chinook salmon on the Anchor River, 1950–2012.

Year(s)	Escapement monitoring
1950s	Periodic fisheries investigations in the Anchor River were conducted by U.S. Fish and Wildlife Service. Chinook salmon escapement was monitored with weirs at various lower river locations on the North and South forks and mainstem. Aerial and foot surveys were also conducted.
1962–1969	Annual Chinook salmon escapement was estimated with a combination aerial and ground index survey. Surveys were conducted once annually over a standard length of river. Aerial surveys were done from a fixed-wing aircraft (Super Cub). Foot surveys were conducted within a subsection of the aerial survey from the Sterling Highway Bridge upstream approximately 4 river kilometers (RKM) to forks. Where the foot survey was conducted, if the foot survey counts were greater than the aerial counts, the total aerial count was expanded by the difference. In 1966, no aerial surveys were conducted due to poor viewing conditions. Note: “standard length” and the location of the Sterling Highway Bridge (old versus new) could not be determined.
1970–1974	The ground index subsection was expanded to approximately 8 RKM from Glanville lumber to forks. No aerial survey was conducted in 1970 or 1971. Note: “forks” is assumed to be North and South forks confluence.
1975–1982	Aerial surveys were conducted using rotary-wing aircraft to index Chinook salmon escapement. Surveys were conducted once annually over a standard section of the South Fork of the Anchor River. Foot surveys continued as before. Note: “forks” is assumed to be North and South forks confluence.
1983–1994	The index subsection for combined aerial and foot surveys was reduced back to approximately 4 RKM from Sterling Highway Bridge to forks. Note: “standard length” and the location of the Sterling Highway bridge (old versus new) could not be determined.
1995–2002	The foot survey was discontinued. Periodic foot surveys were conducted over additional stream reaches such as North Fork, Beaver Creek, and above forks. Aerial surveys continued.
2003	In addition to the aerial survey, the feasibility of using DIDSON[4] sonar as an escapement monitoring tool was tested on the mainstem of the Anchor River just below the confluence of the North and South forks at RKM 2.8. DIDSON was only operated from 30 May through 9 July, not over the entire run.
2004	Chinook salmon escapement was monitored over the entire run at approximately RKM 2.8 through a combination of DIDSON during periods of high water and resistance board weir during periods of low water. A weir was operated on the North Fork to monitor the entire run at approximately RKM 6.2. Aerial surveys of the North Fork and South Fork index areas were used to compare index to total escapement estimates.
2005–2008	Chinook salmon escapement was monitored over the entire run at approximately RKM 2.8 through a combination of DIDSON during periods of high water and resistance board weir during periods of low water. Aerial surveys were continued through 2008 to compare index to total run estimates.
2009	Chinook salmon escapement was censused using a resistance board weir over the entire run at approximately RKM 2.8 because of low water levels. A foot survey of the historical index area was conducted from the new Sterling Highway Bridge (lat 59.746895, long −151.754319) to the confluence of the North and South Forks (lat 59.772253, long −151.834263).

-continued-

4 Dual frequency identification sonar (DIDSON).

Appendix A1.–Page 2 of 2.

Year(s)	Escapement monitoring
2010	Chinook salmon escapement was monitored over the entire run at approximately RKM 2.8 through a combination of DIDSON during periods of high water and resistance board weir during periods of low water. Escapement monitoring in August and September was conducted through a cooperative agreement with USFWS. USFWS monitored escapement using the resistance board weir and an underwater video camera (Anderson and Stillwater Sciences 2011).
2011–2012	Chinook salmon escapement was monitored over the entire run at approximately RKM 2.8 through a combination of DIDSON during periods of high water, and resistance board weir fitted with an underwater video camera during periods of low water. In 2011, escapement monitoring in August and September was conducted through a cooperative agreement with USFWS.

Appendix A2.–Timeline of sport harvest monitoring and escapement goals for Chinook salmon on the Anchor River, 1950–2012.

Year (s)	Sport harvest assessment
1950s	Periodic fisheries investigations in the Anchor River were conducted by U.S. Fish and Wildlife Service. Chinook salmon harvest was monitored through creel surveys.
1966–1977	Punch cards were used to enforce daily and seasonal limits (Hammarstrom et al. 1985).
1971–1977	Punch card returns were the primary source of harvest data. Effort was estimated by car counts each day at campgrounds and parking areas from 1971 to 1976.
1972–1986	Creel surveys were conducted at the Deep Creek access from 1972 to1986 and 1994 (Nelson 1994, 1995). A creel survey at the Anchor River–Whiskey Gulch access was conducted in 1986 (Nelson 1994).
1976–1983	Age composition of the Chinook salmon harvest was estimated for the Anchor River, Deep Creek, and Ninilchik River (Hammarstrom et al. 1985).
1977 to present	Statewide Harvest Surveys (SWHS) were conducted and produced annual estimates of total catch and harvest for Chinook salmon in the Anchor River.

Year (s)	Escapement goals
1993–1997	The first biological escapement goal (BEG) of 1,790 Chinook salmon was adopted in 1993. The BEG was the average of the expanded estimates from aerial and foot survey index counts conducted from 1966 to 1969 and from 1972 to 1991.
1998–2000	In 1998, the BEG was rescaled to a range of 1,050–2,200 Chinook salmon and was based on historical aerial survey counts and their relationship to sport harvest. The escapement range was approximated with a median aerial survey count of 1,211 Chinook salmon. The upper end of the range was the value that 20% of the annual aerial counts were above. The lower end was the value that 40% of the annual aerial counts were below (Szarzi and Begich 2004: page 22).
2001–2004	In 2001, the sustainable escapement goal (SEG) of 750 to 1500 Chinook salmon was adopted. The SEG was the 25th and 75th percentiles of the annual aerial counts from 1976 through 2000 (Szarzi and Begich 2004: page 22). During the Alaska Board of Fisheries (BOF) meeting in February 1999, in response to the guidelines established in the *Sustainable Salmon Fisheries Policy*, BOF designated Anchor River Chinook salmon as a stock of "management concern" defined in the policy as "a concern arising from a chronic inability, despite use of specific management measures, to maintain escapements for a salmon stock within the bounds of the SEG, BEG, [optimal escapement goal] OEG, or other specified management objectives for the fishery" (5 AAC 39.222 [f] [21]) (Szarzi and Begich 2004: page 25).
2005–2007	In 2005, the SEG was repealed and no new goal was adopted in anticipation that SF would collect sufficient escapement data with the DIDSON–weir project to recommend an escapement goal (Szarzi et al. 2007).

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Year (s)	Escapement goals
2008	ADF&G adopted a lower bound SEG of 5,000 Chinook salmon. The SEG was based on a full probability spawner-recruit model that incorporated aerial survey data and SWHS harvest estimates from 1977 to 2007, and the total escapement estimates and age composition data collected from the DIDSON–weir project from 2003 to 2007 (Szarzi et al. 2007)
2010-2012	ADF&G adopted an SEG range of 3,800–10,000 Chinook salmon. The SEG was based on a full probability spawner-recruit model and was updated with escapement and harvest data through 2009. The lower bound of the SEG is the escapement point estimate of maximum sustained yield. The upper bound is the estimated point of carrying capacity (Otis et al. 2010).

Appendix A3.–Timeline of the freshwater fishing regulations and emergency orders (EOs) for Chinook salmon on the Anchor River, 1960–2012.

Closed areas for Chinook salmon	
Year	Chinook salmon fishing regulations
1960–2010	Salmon fishing closed upstream of the confluence of the north and south forks.
1996–2012	The area above “forks” was closed to all fishing until August 1 to protect spawning salmon.

Recording requirements	
Year	Chinook salmon fishing regulations
1966–1980	A Chinook salmon punch card was required by all anglers, including those under 16 years of age.
1980–2012	Anglers recorded Chinook salmon harvest on the back of a sport fishing license or harvest card.

Open season for Chinook salmon by regulation	
Year	Chinook salmon fishing regulations
1960	May 7 to December 31.
1961	May 7 to July 1 only.
1962–1963	May 7 to July 8 only.
1964–1965	Closed.
1966	May 28–June 26 and limited to weekends and holidays or until 500 Chinook salmon 20 inches (in) or longer was attained among the Anchor River, Deep Creek, Ninilchik and Kenai Rivers.
1967	May 27–June 11 opened continuously or until 500 Chinook salmon 20 in or longer was attained among the Anchor River, Deep Creek, Ninilchik and Kenai Rivers.
1968	May 25–June 9 opened continuously or until 500 Chinook salmon 20 in or longer was attained among the Anchor River, Deep Creek, Ninilchik and Kenai Rivers. .
1969	May 24–June 8 opened continuously or until 200 Chinook salmon 20 in or longer was attained among the Anchor River, Deep Creek, Ninilchik and Kenai Rivers.
1970	May 30–June14 opened continuously or until 200 Chinook salmon 20 in or longer was attained among the Anchor River, Deep Creek, Ninilchik and Kenai Rivers.
1971	Beginning on the Memorial Day weekend for 2 consecutive 2-day weekends (Saturday and Sunday). Quota eliminated.
1972	Beginning on the Memorial Day weekend for 2 consecutive 2-day weekends.
1973–1975	Beginning on the Memorial Day weekend for 3 consecutive 2-day weekends.
1976–1977	Beginning on the Memorial Day weekend for 4 consecutive 2-day weekends.
1978–1988	Beginning on the Memorial Day weekend for 4 consecutive 3-day weekends (weekends include Monday).
1989–2001	Beginning on the Memorial Day weekend for 5 consecutive 3-day weekends (weekends include Monday).
2002–2004	Beginning on the Memorial Day weekend for 4 consecutive 3-day weekends (weekends include Monday).
2005–2007	Beginning on the 3-day weekend before the Memorial Day weekend and 4 consecutive 3-day weekends.
2008–2012	Beginning on the 3-day weekend before the Memorial Day weekend and 4 consecutive 3-day weekends. Also the Wednesdays following each weekend opening.

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Bag, possession, and season limits	
Year	Chinook salmon fishing regulations
1960	Bag and possession limit: 3 salmon over 16 inches in length, of which not more than 2 could be Chinook salmon 20 inches or more in length.
1961–1962	Bag and possession limit: 3 salmon over 20 inches in length, of which not more than 1 could be Chinook salmon 20 inches or more in length.
1963	Bag and possession limit: salmon 16 inches or more in length; 6 coho salmon; 3 pink, chum or sockeye salmon; or 1 Chinook salmon.
1964–1965	Closed.
1966–1978	Bag and possession limit: 1 Chinook salmon 20 inches or more in length. Bag and possession limit: 10 Chinook salmon less than 20 inches long. Season limit: 2 Chinook salmon 20 inches or more in length.
1979–1985	Bag and possession limit: 1 Chinook salmon 20 inches or more in length. Bag and possession limit: 10 Chinook salmon less than 20 inches long. Season limit: 5 Chinook salmon 20 inches or more in length.
1986–1995	Bag limit: 1 Chinook salmon 16 inches or more in length. Bag and possession limit: 10 Chinook salmon less than 16 inches long. Season limit: 5 Chinook salmon 16 inches or more in length.
1996–1998	Bag limit: 1 Chinook salmon 16 inches or more in length. Bag and possession limit: 10 Chinook salmon less than 16 inches long. Season limit: 2 Chinook salmon 16 inches or more in length from Deep Creek or the Anchor River combined. After harvesting a Chinook salmon 16 inches or more in length from Deep Creek or the Anchor River, an angler may not fish in either drainage for the rest of that day.
1996–1998	Bag limit: 1 Chinook salmon 16 inches or more in length. Bag and possession limit: 10 Chinook salmon less than 16 inches long. Season limit: 2 Chinook salmon 16 inches or more in length from Deep Creek or the Anchor River combined. After harvesting a Chinook salmon 16 inches or more in length from Deep Creek or the Anchor River, an angler may not fish in either drainage for the rest of that day.
1999–2007	Bag limit: 1 Chinook salmon 20 inches or more in length. Bag and possession limit: 10 Chinook salmon less than 20 inches long. Season limit: 2 Chinook salmon 20 inches or more in length from Deep Creek or the Anchor River combined. After harvesting a Chinook salmon 20 inches or more in length from Deep Creek or the Anchor River an angler may not fish in either drainage for the rest of that day.
2008–2010	Bag limit: 1 Chinook salmon 20 inches or more in length. Bag and possession limit: 10 Chinook salmon less than 20 inches length. Season limit: 5 Chinook salmon 20 inches or more in length.
2011–2012	Bag limit: 1 Chinook salmon 20 inches or more in length. Bag and possession limit: 10 Chinook salmon less than 20 in length. Season limit: 2 Chinook salmon 20 inches or more in length from Deep Creek or the Anchor River combined. After harvesting a Chinook salmon 20 inches or more in length from Deep Creek or the Anchor River an angler may not fish in either drainage for the rest of that day.

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Emergency orders (EOs)	
Year	Chinook salmon fishing regulations
1971	EO extended the Chinook salmon fishery on Anchor River and Deep Creek an additional 2-day weekend due to low catches (Nelson 1972)
1972	EO extended the Chinook salmon fishery on Anchor River and Deep Creek an additional 2-day weekend due to low catches (Nelson 1972).
1988	EO 2-KS-1-04-88 extended the Chinook salmon fishery on Anchor River and Deep Creek an additional weekend. Highly turbid river conditions early in the season depressed angler success rates and managers' expectations (D. C. Nelson, unpublished[5]).
2004	EO 2-KS-7-07-04 opened the Anchor River Chinook salmon fishery from 12:00 AM on Saturday, June 26 through 11:59 PM on June 28 from the mouth of the Anchor River to 600 ft downstream of the confluence of the north and south forks. Bag limit: 1 Chinook salmon per day.
2009	EO 2-KS-7-08-09 closed the Anchor River drainage from its mouth upstream to the north and south forks to fishing and increased the closed area in the salt waters of Cook Inlet at the mouth of the Anchor River from 2 miles to 4 miles beginning 12:01 AM on Saturday, June 6 through 11:59 PM on Tuesday, June 30.
2010	EO 2-KS-7-10-10 prohibited the use of bait in the Anchor River, Deep Creek, and Ninilchik River drainages and increased the closed area in the salt waters of Cook Inlet at the mouth of the Anchor River from 1 to 2 miles north and south of the Anchor River mouth and 1 mile offshore beginning 12:01 AM on Saturday, June 5 through 11:59 PM on Wednesday, June 30. EO 2-KS-7-15-10 prohibited the retention of Chinook salmon in the Anchor River drainage from its mouth upstream to the junction of the north and south forks beginning 12:01AM on Saturday, June 12 through 11:59 PM on Wednesday, June 30. Chinook salmon may not be possessed or retained; Chinook salmon caught may not be removed from the water and must be released immediately. EO 2-KS-7-10-10 which prohibited the use of bait in the Anchor River, Deep Creek, and Ninilchik River drainages remained in effect. EO 2-KS-7-28-10 closed the salt waters of Cook Inlet at the mouth of the Anchor River to all sport fishing from 2 miles north and south of the Anchor River mouth and 1 mile offshore beginning 12:01 AM on Thursday, July 1 through 11:59 PM on Saturday, July 31. EO 2-KS-7-36-10 rescinded EO 2-KS-7-28-10 issued June 29. Effective 12:01 AM on Tuesday, July 13, the salt waters of Cook Inlet at the mouth of the Anchor River from 2 miles north and south of the Anchor River mouth and 1 mile offshore were open to all sport fishing.
2011	EO 2-KS-7-06-11 prohibited the use of bait in the Anchor River, Deep Creek, and Ninilchik River drainages beginning June 11 through 11:50 PM, Wednesday, June 22. EO 2-KS-7-07-11 closed the waters of the Anchor River drainage from its mouth upstream to the junction of the North and South forks to sport fishing beginning 12:01 AM, Wednesday, June 15 through 11:59 PM, Thursday, June 30. EO 2-KS-7-16-11 required the use of only 1 unbaited, single-hook, artificial lure in the flowing waters of the Anchor River drainage, and closed the salt waters of Cook Inlet at the mouth of the Anchor River to all sport fishing from 2 miles north and south of the Anchor River mouth and 1 mile offshore beginning 12:01 AM, Friday, July 1 through 11:59 PM, Sunday, July 31.

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[5] Nelson, D. C. *Unpublished*. A review of Alaska's Kenai Peninsula east side beach recreational razor clam (Siliqua patula, Dixon) fishery, 1965-1980. Alaska Department of Fish and Game, Division of Sport Fish, Soldotna, Alaska.

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Emergency orders (EOs)	
Year	Chinook salmon fishing regulations
	EO 2-KS-7-08-12 closed waters of the Anchor River drainage from its mouth upstream to the junction of the north and south forks to sport fishing each Wednesday during the Chinook salmon season beginning 12:01 AM, Saturday, May 19. In addition, this EO also decreases the waters of the Anchor River drainage open to sport fishing by relocating the ADF&G regulatory marker downstream approximately 1,000 feet below the junction of the north and south forks beginning 12:01 AM, Saturday, May 19 through 11:59 PM, Tuesday, July 31.
	EO 2-KS-7-09-12 limits sport fishing gear to only 1 unbaited, single-hook, artificial lure when fishing in the Anchor River, Deep Creek, and Ninilchik River drainages beginning 12:01 AM, Saturday, June 2 through 11:59 PM, Wednesday, June 20.
	EO 2-KS-7-10-12 closes waters of the Anchor River drainage from its mouth upstream to the junction of the north and south forks to sport fishing beginning 12:01 AM., Saturday, June 9 through 11:59 PM, Saturday, June 30.
	EO 2-KS-7-13-12 prohibited sport fishing within 1 mile of shore in the salt waters of Cook Inlet south of the latitude of the mouth of the Ninilchik River to the latitude of Bluff Point beginning 12:01 AM, Friday, June 15 through 11:59 PM, Saturday, June 30.
2012	EO 2-KS-7-21-12 closed waters of the Anchor River and Ninilchik River, from the mouth upstream approximately 2 miles to ADF&G markers, to sport fishing for any species of fish, beginning 12:01 AM, Sunday, July 1 through 11:59 PM, Sunday, July 15.
	EO 2-KS-7-22-12 limited sport fishing gear to only 1 unbaited, single-hook, artificial lure when fishing in the Ninilchik River, Deep Creek, Stariski Creek, and Anchor River drainages beginning 12:01 AM, Sunday, July 1 through 11:59 PM, Tuesday, July 31.
	EO 2-KS-7-23-12 prohibited the retention of Chinook salmon while sport fishing within 1 mile of shore in the salt waters of Cook Inlet south of the latitude of the mouth of the Ninilchik River to the latitude of Bluff Point beginning 12:01 AM, Sunday, July 1 through 11:59 PM, Sunday, July 15. Catch-and-release fishing for Chinook salmon is allowed, but Chinook salmon may not be retained or possessed. Chinook salmon that are caught may not be removed from the water and must be released immediately.
	EO 2-KS-7-41-12 prohibited the retention of Chinook salmon while sport fishing within 1 mile of shore in the salt waters of Cook Inlet south of the latitude of the mouth of the Ninilchik River to the latitude of Bluff Point beginning 12:01 AM, Monday, July 16 through 11:59 PM, Tuesday, July 31. Catch-and-release fishing for Chinook salmon is allowed, but Chinook salmon may not be retained or possessed. Chinook salmon that are caught may not be removed from the water and must be released immediately.

APPENDIX B: DAILY ESCAPEMENT COUNTS AT THE ANCHOR RIVER SONAR-WEIR SITE, 2012

Appendix B1.–Daily and cumulative (cum.) escapement counts of Chinook salmon; Dolly Varden; and pink, chum, sockeye, and coho salmon at the Anchor River sonar-weir site, 2012.

	Chinook [a]			Dolly Varden			Pink			Chum			Sockeye			Coho		
Date	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%
14 May	9	9	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
15 May	63	72	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
16 May	18	90	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
17 May	21	111	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
18 May	6	117	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
19 May	21	138	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
20 May	9	147	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
21 May	18	165	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
22 May	18	183	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
23 May	18	201	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
24 May	12	213	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
25 May	18	231	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
26 May	9	240	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
27 May	18	258	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
28 May	30	288	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
29 May	36	324	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
30 May	72	396	9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
31 May	84	480	11	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1 Jun	123	603	13	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2 Jun	69	672	15	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
3 Jun	147	819	18	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
4 Jun	105	924	20	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
5 Jun	186	1,110	25	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
6 Jun	210	1,320	29	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
7 Jun	129	1,449	32	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
8 Jun	135	1,584	35	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
9 Jun	162	1,746	39	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
10 Jun	126	1,872	42	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
11 Jun	111	1,983	44	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
12 Jun	138	2,121	47	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

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	Chinook [a]			Dolly Varden			Pink			Chum			Sockeye			Coho		
Date	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%
13 Jun [b]	139	2,260	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14 Jun	86	2,346	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15 Jun	29	2,375	53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16 Jun	12	2,387	53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17 Jun	39	2,426	54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 Jun	110	2,536	56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19 Jun	123	2,659	59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20 Jun	25	2,684	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 Jun	45	2,729	61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22 Jun	98	2,827	63	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
23 Jun	76	2,903	64	0	0	0	5	6	2	0	0	0	0	0	0	0	0	0
24 Jun	81	2,984	66	0	0	0	2	8	2	0	0	0	0	0	0	0	0	0
25 Jun [c]	52	3,036	67	0	0	0	0	8	2	0	0	0	0	0	0	0	0	0
26 Jun [c]	5	3,041	67	0	0	0	0	8	2	0	0	0	0	0	0	0	0	0
27 Jun	1	3,042	67	0	0	0	0	8	2	0	0	0	0	0	0	0	0	0
28 Jun	6	3,048	68	0	0	0	0	8	2	0	0	0	0	0	0	0	0	0
29 Jun	21	3,069	68	4	4	0	0	8	2	0	0	0	0	0	0	0	0	0
30 Jun	25	3,094	69	12	16	1	1	9	3	0	0	0	0	0	0	0	0	0
1 Jul	12	3,106	69	0	16	1	0	9	3	0	0	0	0	0	0	0	0	0
2 Jul	75	3,181	71	2	18	1	25	34	11	0	0	0	0	0	0	0	0	0
3 Jul	12	3,193	71	8	26	1	6	40	12	0	0	0	0	0	0	0	0	0
4 Jul	6	3,199	71	1	27	1	5	45	14	0	0	0	0	0	0	0	0	0
5 Jul	45	3,244	72	13	40	2	1	46	14	0	0	0	0	0	0	0	0	0
6 Jul	31	3,275	73	21	61	3	0	46	14	0	0	0	0	0	0	0	0	0
7 Jul	27	3,302	73	38	99	5	2	48	15	1	1	4	0	0	0	0	0	0
8 Jul	37	3,339	74	31	130	6	0	48	15	0	1	4	0	0	0	0	0	0
9 Jul	19	3,358	74	44	174	8	6	54	17	0	1	4	0	0	0	0	0	0
10 Jul	64	3,422	76	41	215	10	6	60	19	0	1	4	0	0	0	0	0	0
11 Jul	35	3,457	77	15	230	11	5	65	20	1	2	7	0	0	0	0	0	0
12 Jul	16	3,473	77	15	245	12	1	66	21	1	3	11	0	0	0	0	0	0
13 Jul	27	3,500	78	14	259	12	1	67	21	0	3	11	0	0	0	0	0	0

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	Chinook [a]			Dolly Varden			Pink			Chum			Sockeye			Coho		
Date	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%
14 Jul	35	3,535	78	91	350	16	2	69	21	0	3	11	0	0	0	0	0	0
15 Jul	35	3,570	79	22	372	18	1	70	22	2	5	19	0	0	0	0	0	0
16 Jul	94	3,664	81	36	408	19	0	70	22	1	6	22	0	0	0	0	0	0
17 Jul	171	3,835	85	609	1,017	48	13	83	26	3	9	33	2	2	5	0	0	0
18 Jul	62	3,897	86	180	1,197	56	6	89	28	4	13	48	0	2	5	0	0	0
19 Jul	57	3,954	88	191	1,388	65	4	93	29	1	14	52	0	2	5	0	0	0
20 Jul	29	3,983	88	149	1,537	72	4	97	30	3	17	63	1	3	7	0	0	0
21 Jul	52	4,035	89	56	1,593	75	13	110	34	2	19	70	1	4	9	0	0	0
22 Jul	203	4,238	94	51	1,644	77	54	164	51	1	20	74	1	5	12	0	0	0
23 Jul	24	4,262	95	46	1,690	80	17	181	56	1	21	78	2	7	16	0	0	0
24 Jul	12	4,274	95	51	1,741	82	10	191	60	0	21	78	1	8	19	0	0	0
25 Jul	11	4,285	95	60	1,801	85	13	204	64	0	21	78	2	10	23	0	0	0
26 Jul	12	4,297	95	123	1,924	91	10	214	67	1	22	81	3	13	30	2	2	6
27 Jul	17	4,314	96	66	1,990	94	2	216	67	1	23	85	2	15	35	0	2	6
28 Jul	31	4,345	96	76	2,066	97	30	246	77	0	23	85	4	19	44	4	6	19
29 Jul	35	4,380	97	35	2,101	99	11	257	80	0	23	85	3	22	51	2	8	25
30 Jul	22	4,402	98	17	2,118	100	17	274	85	1	24	89	2	24	56	2	10	31
31 Jul	65	4,467	99	1	2,119	100	26	300	93	1	25	93	8	32	74	6	16	50
1 Aug	19	4,486	99	2	2,121	100	5	305	95	0	25	93	4	36	84	10	26	81
2 Aug	15	4,501	100	3	2,124	100	11	316	98	1	26	96	7	43	100	3	29	91
3 Aug	8	4,509	100	1	2,125	100	5	321	100	1	27	10	0	43	100	3	32	100

Note: A single steelhead was counted through the weir on 24 July. Based on steelhead life history, counts from 24 May through 30 June are considered prespawning fish and counts from 31 July to 21 September are fall immigrants. En dash denotes no information.

[a] Escapement census using DIDSON expanded counts (2,247 SE 100) from 14 May to 13 June and weir counts (2,171) from 13 June to 3 August.

[b] Daily count based on 126 fish estimated from 0000 to 1300 hours using DIDSON and 13 Chinook salmon counted from 1400 to 2359 using the underwater video system.

[c] Weir compromised by high water.

APPENDIX C: COUNTS BASED ON DIDSON FILES

Appendix C1.–Daily upstream, downstream, and net counts based on DIDSON files, Anchor River, 2012.

Date	Upstream	Downstream	Net count [a]	Minutes counted
14 May	5	2	3	280
15 May	22	1	21	480
16 May	7	1	6	480
17 May	8	1	7	480
18 May	4	2	2	480
19 May	8	1	7	480
20 May	4	1	3	480
21 May	9	3	6	480
22 May	8	2	6	480
23 May	8	2	6	480
24 May	6	2	4	480
25 May	6	0	6	480
26 May	7	4	3	480
27 May	6	0	6	480
28 May	13	3	10	480
29 May	14	2	12	480
30 May	25	1	24	480
31 May	40	12	28	480
1 Jun	65	24	41	480
2 Jun	39	16	23	480
3 Jun	50	1	49	480
4 Jun	43	8	35	480
5 Jun	90	28	62	480
6 Jun	79	9	70	480
7 Jun	65	22	43	480
8 Jun	80	35	45	480
9 Jun	79	25	54	480
10 Jun	65	23	42	480
11 Jun	56	19	37	480
12 Jun	69	23	46	480
13 Jun	78	36	42	280
Total	1,058	309	749	14,480

[a] Net count equals upstream count minus downstream count.

APPENDIX D: DAILY RIVER STAGE AVERAGES FOR THE SOUTH FORK ANCHOR RIVER, 2012

Appendix D1.–Daily river stage averages for the south fork of the Anchor River, 2012.

	Daily river stage average (cm) [a]											
Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	25.6	108.8	72.3	69.7	89.3	61.7	39.2	37.0	60.8	46.4	36.6	32.1
2	47.1	114.3	74.3	71.1	76.2	61.7	36.9	38.0	51.5	45.1	44.7	31.7
3	44.9	91.3	65.3	70.8	67.5	68.3	35.2	34.4	50.6	44.4	49.5	26.0
4	39.8	63.2	66.6	62.8	64.1	64.0	43.0	30.7	45.2	58.2	53.4	28.3
5	54.0	84.4	69.3	60.7	66.8	58.4	40.6	30.3	45.9	54.5	63.7	21.8
6	52.7	79.7	70.1	76.1	69.0	56.5	37.8	29.9	43.7	74.6	74.7	18.3
7	73.4	86.6	67.8	90.0	76.7	56.6	34.8	27.9	36.9	63.7	78.0	17.2
8	74.0	101.6	67.6	96.3	79.5	53.1	33.3	27.0	38.3	57.5	91.0	20.3
9	38.8	96.3	65.6	81.8	85.2	50.4	32.0	25.8	38.9	52.8	104.6	23.5
10	78.4	106.0	62.9	77.0	80.8	49.5	37.3	24.7	33.6	49.6	102.1	28.4
11	90.2	102.5	61.5	71.1	78.4	48.7	33.5	24.6	31.3	47.0	97.0	32.4
12	65.6	98.6	63.6	71.7	76.8	46.0	32.2	23.7	34.9	45.1	93.3	47.7
13	27.9	90.4	65.6	79.2	73.8	48.3	33.0	23.2	36.1	43.5	89.6	64.6
14	-7.6	81.9	66.4	84.1	74.6	58.7	31.9	22.7	32.7	42.6	91.0	60.7
15	0.4	75.6	65.9	85.1	78.8	57.7	37.3	22.2	36.5	45.3	89.2	31.6
16	1.9	73.3	64.6	90.0	82.9	49.4	38.0	22.0	77.5	44.4	81.4	20.4
17	7.9	75.8	63.4	99.1	86.6	44.8	32.9	21.7	68.8	41.4	65.7	16.1
18	8.4	74.0	61.3	112.3	87.7	41.4	30.0	22.3	64.3	38.5	74.7	7.3
19	21.7	69.2	59.7	110.5	85.1	39.5	28.1	26.4	99.8	33.9	69.9	6.2
20	60.7	69.5	57.4	86.3	85.8	38.1	26.8	25.3	107.6	33.0	56.0	7.0
21	71.0	73.4	58.6	83.1	85.9	37.6	30.2	25.0	78.7	32.7	59.1	6.7
22	93.4	71.2	57.4	82.3	91.4	35.9	46.4	23.0	88.9	31.0	63.0	7.5
23	85.6	64.3	54.7	82.2	90.0	34.0	39.8	33.6	78.8	28.6	63.5	7.2
24	82.3	65.8	56.6	79.8	93.2	40.4	35.2	33.8	69.8	27.0	55.1	7.9
25	77.3	67.0	58.2	72.0	90.8	45.8	32.6	28.4	60.7	26.9	49.0	5.4
26	59.2	66.5	57.1	78.4	84.5	73.1	29.8	25.4	61.2	26.6	37.2	9.9
27	43.8	68.0	56.3	82.2	85.4	56.1	27.9	27.8	60.1	25.1	40.5	14.7
28	41.3	69.5	59.6	82.4	80.0	49.9	26.2	25.0	57.7	24.4	39.1	10.5
29	66.2		63.7	83.8	76.4	46.2	25.1	22.8	53.6	27.9	40.1	22.7
30	77.8		65.7	90.3	71.3	42.4	40.8	23.2	48.9	30.1	44.2	28.1
31	82.4		67.4		65.1		43.6	37.2		30.9		15.7

Source: Retrieved on 2014-09-25 19:40:37 EDT (nadww01) from http://waterdata.usgs.gov/ak/nwis/uv/?site_no=15239900&PARAmeter_cd=00065,00060.

[a] Stage data were collected at gauge station USGS 15239900, located approximately 11.4 RKM on the south fork, Anchor River.

Appendix D2.–Daily river temperature average (°C), Anchor River, 2012.

	Daily temperature average (°C)														
	May			June			July			August			September		
Day	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
1	1.8	0.5	3.4	6.5	4.6	9.0	13.3	11.5	15.7	10.8	10.4	11.3	9.8	9.1	10.6
2	1.8	0.2	3.5	7.3	5.1	10.0	12.4	10.2	15.2	10.3	9.7	10.9	9.1	8.7	9.9
3	1.8	0.8	2.9	7.0	6.3	7.9	10.9	10.2	12.5	10.7	8.7	13.3	9.5	9.1	10.2
4	2.4	0.9	4.0	6.6	5.7	7.6	9.6	8.8	10.3	10.3	9.8	11.3	8.7	8.4	9.7
5	2.6	1.6	3.5	8.2	5.5	11.4	9.6	8.8	10.6	10.3	8.7	12.2	8.6	8.1	9.1
6	2.6	1.9	3.2	7.6	6.7	9.9	9.9	8.7	11.0	11.8	10.0	14.3	8.7	7.9	9.8
7	3.2	1.5	5.0	8.4	6.3	11.2	10.4	9.1	11.7	12.1	10.2	13.8	8.2	7.4	8.7
8	3.6	1.5	6.0	9.6	7.3	12.0	10.1	8.4	12.1	12.7	10.6	15.6	8.0	7.3	8.9
9	3.1	1.9	4.5	10.2	8.8	11.8	10.4	9.1	12.3	13.3	11.3	15.6	7.2	5.7	8.7
10	2.9	1.8	4.0	9.3	7.7	10.9	10.1	8.0	12.0	12.8	12.1	13.6	6.5	4.9	8.0
11	3.5	2.2	4.9	9.7	6.8	12.8	9.7	9.0	10.9	12.2	9.4	15.2	6.2	5.4	6.8
12	3.2	2.1	4.1	10.2	9.4	11.2	9.0	8.3	10.0	12.4	9.8	15.3	7.1	6.3	8.3
13	3.5	2.2	5.3	8.7	8.1	9.3	10.4	8.5	12.7	13.7	11.8	16.6	7.3	5.9	8.8
14	4.4	2.1	6.9	8.6	7.4	10.4	10.5	9.4	11.5	13.6	12.5	14.9	7.8	7.0	8.7
15	4.8	2.5	7.1	8.3	6.6	9.7	9.8	9.3	10.3	13.0	11.8	14.1	7.7	7.4	8.0
16	4.7	2.2	7.2	10.2	7.4	13.4	11.2	8.7	14.6	12.4	11.3	13.5	7.7	7.4	8.1
17	4.8	2.3	7.3	12.5	9.6	15.9	12.4	9.6	15.7	12.2	10.6	14.4	7.9	7.3	8.5
18	4.3	2.2	5.9	12.9	10.8	15.0	12.8	9.8	16.0	10.3	8.8	12.0	7.8	7.6	8.2
19	4.4	3.0	5.7	12.9	10.6	15.2	13.7	11.2	16.6	10.3	9.6	11.1	8.3	7.8	9.1
20	4.5	3.3	5.6	12.3	11.2	13.7	13.3	12.0	14.8	11.2	9.9	13.4	9.0	8.8	9.3
21	5.2	3.4	7.4	13.0	9.9	16.8	12.5	12.0	13.4	11.9	9.9	14.7	8.9	8.4	9.2
22	5.5	4.0	7.1	14.8	11.7	18.3	11.3	10.7	11.9	11.1	8.8	13.4	9.3	8.9	9.8
23	6.2	4.0	8.8	15.1	12.1	18.4	10.6	10.2	11.0	10.8	10.2	11.8	9.2	8.8	9.7
24	6.0	4.1	8.0	13.2	11.8	15.3	11.3	9.9	13.5	9.7	8.6	10.5	7.9	7.3	9.0
25	5.7	4.8	7.1	10.5	9.8	11.8	11.8	9.1	14.8	10.4	8.3	13.0	7.3	6.9	7.5
26	5.8	4.2	7.8	9.5	8.5	10.7	12.0	9.9	14.0	10.8	9.8	12.0	6.4	6.1	7.1
27	5.7	4.8	6.6	10.6	8.5	13.1	12.8	9.8	16.4	12.3	10.7	14.6	6.3	5.7	7.1
28	6.0	4.5	8.1	10.5	9.7	11.6	13.9	11.5	16.8	11.0	8.6	13.3	6.4	5.6	6.8
29	6.1	4.6	7.5	11.9	9.4	15.1	12.3	11.4	14.1	10.3	7.9	12.9	4.9	4.3	5.6
30	5.4	4.6	6.7	12.7	9.8	15.6	10.9	10.2	11.5	10.5	10.1	11.2	3.7	2.9	4.5
31	5.2	4.4	6.0				11.0	9.9	12.4	9.7	9.4	10.1			

Source: Temperature data collected by Sue Mauger of Cook Inletkeeper 0.1 RKM downstream of the resistance board weir.